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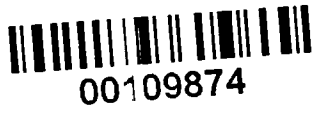

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REPORT

OF AN

INVESTIGATION INTO THE CAUSES OF

MALARIA IN BOMBAY

AND THE MEASURES NECESSARY FOR ITS CONTROL

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BY

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BOMBAY
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PREFACE.

In presenting this report upon "The Causes of Malaria in Bombay and the Measures Necessary for its Control" I desire to acknowledge the great assistance afforded to me in the work of investigation by the members of the Malaria Investigation Committee. But for the facilities freely granted to me by the Municipal Commissioners Mr. W. D. Sheppard, I. C. S., and Mr. P. R. Cadell, I. C. S., the work of investigation in the City generally would have been impossible; and the cordial help given me by the Honourable Mr. J. P. Orr, I. C. S., Chairman of the City of Bombay Improvement Trust, Mr. W. C. Symes and Mr. A. H. Froom representing the Port Trust and Mr. A. Muirhead and Dr. A. H. Deane representing the G. I. P. and B. B. & C. I. Railway Companies, respectively, lightened the work in special areas to a very great extent.

I am greatly indebted also to Dr. J. A. Turner, the Executive Health Officer of Bombay, for much valuable information, for returns regarding sickness and for many specimens of mosquito larvæ collected by officers of the Health Department. My thanks are also due to Colonel W. B. Bannerman, I. M. S., Director, and Major W. G. Liston, I. M. S., Acting Director, of the Bombay Bacteriological Laboratory at Parel, for the facilities placed at my disposal there and for advice and help which has been of the greatest assistance.

The work of investigation in areas controlled by the Port Trust was greatly simplified by help afforded to me on many occasions by Mr. P. Glynn Messent, M.I.C.E., Chief Engineer of the Bombay Port Trust, and Dr. S. A. Powell, Chief Medical Officer, and Messrs. Price, Wills and Reeves, the Contractors for the New Dock, granted me every facility for carrying on the enquiry in the New Dock Works.

Much of the information given in Part I and Chapter I of Part II of the report was derived from the pages of the recently published Gazetteer of Bombay City, and the Administration Reports of the Municipality. A special report by Dr. J. A. Turner, Executive Health Officer, which contained detailed information regarding the anti-malaria measures adopted in the City from time to time, was most useful in drawing up the Chapter on "The History of Malaria Prevention in Bombay."

Section 1 of Chapter IV in Part III which deals with "The Cost of Mosquito Prevention in different parts of the World" is largely based upon information derived from Major Ross' recent book on "The Prevention of Malaria" which has also suggested to some extent the general arrangement adopted in this report; and Sir Rupert Boyce's "Mosquito or Man," and "Health Administration in the West Indies" was of assistance in dealing with "The Legal Aspect of Malaria Prevention." Colonel W. C. Gorgas, U. S. A., not only provided the formula for his valuable larvacide, but supplied reprints of a number of his papers dealing with mosquito prevention and they have been freely quoted from in this report.

My assistants in the investigation were Assistant Surgeon D. A. Vaz, L.M. & S., and Sub-Assistant Surgeons T. G. Akula and Keshavlal G. Modi, and Mr. J. D. A. Fernandes acted as clerk, and I desire to express my appreciation of their work. During a period of three months from May 1st to August 1910 Dr. R. B. Khambata, D.P.H., was attached to the staff of the investigation and afforded much useful assistance.

CHAS. A. BENTLEY.

Bombay, April 1911.

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SALT PANS
MAHIM
SION
DADAR
MATUNGA
WADALA
SEWRI
PAREL
JACOB CIRCLE
MAHALAXMI
WORLI
BANDRA
KURLA
GHATKOPAR
SANTACRUZ
ANDHERI
JUHU
VERSOVA
POWAI
VIHAR
TULSI
MALAD
KANDIVLI
BORIVLI
DAHISAR
MIRA
BHAYANDAR
VASAI

MAP
OF THE TOWN AND
ISLAND OF BOMBAY.
Scale, 2400 Ft = 1 Inch.
Ward Boundaries
Section Boundaries
Reduced to ½ Scale
Govt Photozincographic Office, Poona, 1911

PART I.—INTRODUCTORY.

CHAPTER I.

BRIEF DESCRIPTION OF BOMBAY.

Section 1.

1. The City of Bombay, the capital of the Bombay Presidency and the principal seaport of Western India, is situated on an island on the shore of the Arabian Sea in 18° 55′ N. and 72° 54′ E. This island forms one of a group lying off the coast of the Konkan. It is now permanently united to a larger island, Salsette, and the mainland by means of causeways, bridges and breakwaters. Originally seven small islands, separated from one another by narrow channels and enclosing a large central lagoon, occupied the site of the present island, as may be seen by reference to map No. II; but gradually these islands were connected by causeways and, embankments and, after the construction of the great Hornby Vellard, the island of Bombay assumed its present form. Since that time a considerable area of foreshore has been reclaimed and a large amount of low-land has been filled in, but even now much of the central portion of the island is below sea level. Reference to map No. III, in which the shaded portion represents land below sea level, will show this.

2. Physically the island consists of a low-lying alluvial plain or shallow valley between two parallel ranges of low broken hills. To the south these two ranges are represented by the respective promontories of Malabar Hill and Colaba Point, which jut into the sea and partly enclose a large shallow expanse of water known as Back Bay. The hills on the island are all small, reaching an elevation a little more than 150 feet. There are no rivers or permanent natural streams; but as the centre of the island, towards the north, forms a basin shaped depression, it is subject to temporary flooding during the rainy season.

3. The climate of Bombay is warm, equable and humid. The average mean annual temperature is 79·6° Fah., January being the coldest month with an average mean temperature of 73·9° and May the warmest with an average mean temperature of 84·7°. The seasons may be conveniently divided into the wet and the dry. The wet season usually begins in June when the monsoon bursts and continues until the middle or end of October. After the onset of the rains the temperature falls slightly, but remains remarkably uniform, almost within 1° of the mean of the year, until October, when a slight rise occurs. From October the temperature falls gradually until January, after which it rises again to the maximum in May. Table I in the appendix gives the average temperature observed from 1873—1905 and the actuals recorded during 1906—1910.

There is no forest or jungle and little natural undergrowth on the island. Up to 1872 more than half the island was under cultivation, large areas being used for rice, plantations of toddy palms and market gardens; but in 1909 only a little over 2,000 acres was cropped, chiefly in the north of the island. Of this area over 800 acres were covered with toddy palms, nearly 500 acres with rice and the remainder was used for market gardens.

4. The average annual rainfall for Bombay is 71·15 inches. The maximum fall recorded in one year is 114·89 and the minimum 33·42. The average number of rainy days in the year is 103.

The following table shows the annual rainfall of Bombay for a number of past years:—

Year.	Inches.	Year.	Inches.	Year.	Inches.
1843	52·24	1853	62·60	1863	77·68
1844	62·71	1854	82·14	1864	45·57
1845	54·12	1855	41·18	1865	77·85
1846	73·93	1856	65·92	1866	78 44
1847	76·00	1857	51·27	1867	62·30
1848	75·86	1858	62·45	1868	62·12
1849	114·89	1859	77·16	1869	91 66
1850	50·25	1860	62·15	1870	66·21
1851	96 07	1861	76·01	1871	40·58
1852	69·27	1862	73·63	1872	76·48

Year.	Inches.	Year.	Inches.	Year.	Inches.
1873	69·70	1886	99·74	1899	35·90
1874	82·18	1887	94·95	1900	69·12
1875	78·29	1888	57 82	1901	75·32
1876	46·70	1889	67·84	1902	71·97
1877	64·73	1890	65·18	1903	84·49
1878	106·13	1891	77·18	1904	38·42
1879	61·40	1892	95·12	1905	33·66
1880	67·94	1893	67·24	1906	56·30
1881	73·04	1894	66·85	1907	100·78
1882	69·23	1895	67·59	1908	53 54
1883	90·18	1896	87·65	1909	71·22
1884	75·44	1897	81·53	1910	67·83
1885	67·91	1898	74·09		

5. The atmosphere of Bombay is generally moist, the lowest relative humidity 0·668* occurs late in December. During December, January and February it remains fairly uniform, but from then onwards gradually increases. With the fall of temperature which occurs in June after the onset of the rains the relative humidity increases, and the maximum 0·867 is reached about the middle of July. From July to September there is little fluctuation but about the middle of October a somewhat sharp fall occurs. The diurnal variations in the relative humidity is most marked in the dry weather. In December when at 2 p.m. the humidity is only 0·554 at 6 a.m. it is 0·673 ; but in July the respective figures are 0·841 and 0·895.

6. The prevailing winds vary according to season. During the monsoon months the wind blows from W.S.W. The maximum velocity is 18·8 miles per hour and is attained in July. By November the prevailing winds come from the N.E., but from January onwards the easterly component gradually disappears and is replaced in March by a westerly one. About the middle of May the northerly component is replaced by a southerly one and from then onwards south-westerly winds increase in strength to their maximum in July.

Section 2. 7. THE POPULATION OF BOMBAY.—The population of Bombay is an altogether abnormal one. It may be said to be composed of—.

(1) A fixed and permanent population.

(2) A floating population (A) varying in numbers from year to year.

(3) A second floating population (B) varying in numbers from season to season.

(4) A third floating population (C) composed of people passing through the City and resident for only brief periods.

8. The fixed population mainly consists of those born in Bombay, together with a certain number of persons from the Bombay Presidency and other parts, who may be said to have made Bombay their home. The floating population (A) is composed of those who come to reside in Bombay for business and other purposes, and who remain for periods of one or more years. The floating population (B) consists of people of the labouring class, who visit Bombay in search of employment during the dry weather, returning to their own homes just before the onset of the rainy season. The floating population (C) includes visitors for short periods, travellers by rail and steamer who are constantly arriving and departing, the crews of vessels in the harbour and pilgrims who pass through on their way to Mecca.

Of the total population more than four-fifths are concentrated in the southern half of the island. Thus the one half of the island contains a population averaging 200 to the acre, whereas the other shows an average of only 20 to the acre.

9. There is probably no city in the world in which a larger number of different races is to be met with than in Bombay; this is shown by the fact that at the Census of 1901, 62 different dialects were recorded as being spoken in the City.

* 1·000 denotes complete saturation.

The following table indicates the places from which the extraordinarily mixed population of Bombay is drawn :—

Birth places.	1872.		1881.		1891.		1901.		1906.
Bombay City	200,613		214,685		205 732		181,834		203,692
Bombay Presidency ..	355,437		456,586		488,938		477,650		636,974
Other Provinces of India ...	61,325		69 619		110,037		101,085		
Asia, other than India ...	5,757		7,907		6,467		6,304		
Europe	4,950	83,355	6,023	10 ,925	7,663	127,094	7,707	116,522	137,156
Africa	1 275		619		736		694		
America	87		114		170		162		
Other places	14,961		17,643		2,021		570		

10. Of the total population only about 21 per cent., according to the Census of 1906, are born within the City. Since 1872 there has been a progressive fall in the proportion of Bombay born citizens and a corresponding rise in the proportion of those belonging to districts in the Presidency.

Year.	Total.	Bombay born.	Districts in Bombay Presidency.	Outside Bombay Presidency.
		Per cent.	Per cent.	Per cent.
1872	644,405	31·1	55·1	13·7
1881	773,196	27·7	59·0	13·1
1891	821,764	25·0	59·4	15·4
1901	776,006	23·4	61·5	15·0
1906	977,822	20·8	65·1	14·0

As has already been mentioned, besides those who come from other places and settle down permanently or for a few years in Bombay, a very large proportion of the total population is composed of people who come to the City in search of employment at certain times of the year, and leave again after a few months to return to their own homes. The floating population of this kind is probably not less than 150,000 to 200,000 persons. The influx of these people commences in November and continues throughout the dry weather. The exodus occurs in May and June. As the Census figures are recorded in February or March, they include nearly the whole of this temporary floating population.

The following Districts and States in the Bombay Presidency contribute very largely to the City population :—

District.	1901.	1906.
Ratnágiri	145,835	221,572
Poona	64,791	76,138
Sátára	60,387	61,777
Káthiáwár	45,531	67,803
Cutch	28,179	38,112
Surat	25,097	33,954
Kolába	21,100	29,867

11. The following table shows the population according to race, etc. :—

	1872.	1881.	1891.	1901.	1906.
Hindu	408,680	502,851	568,501	508,608	706,154
Jain	15,121	17,218	...	14,248	
Mussulman	138,815	158,713	165,247	155,747	168,677
Christians Native ...	25,119	30,708	29,432	29,645	30,223
European and Eurasian ...	9,605	11,619	15,878	15,531	18,285
Parsi	44,091	48,597	47,458	46,231	48,824
Others	2,974	3,490	5,248	5,996	5,659

12. *Education.*—No city in India is more advanced as regards education than Bombay. At the Census of 1901 nearly 20 per cent. of the total population was found to be literate, a proportion which is very high for India. Among Indian born persons the Parsis, as a community, showed the highest percentage of literates among both males and females. Education is rapidly developing in Bombay; there are many elementary schools in the City, a fair number of higher class schools, and the University. A large medical school is attached to the University from which about 100 qualified medical men pass out each year.

13. *Occupation.*—At the Census of 1906 a total of 588,713 persons were returned as workers and 389,109 as dependents and non-workers. Among the workers 502,544 were males and 86,169 females. It is sometimes imagined, because women may be seen working as coolies, that it is a customary thing in India for women of the poorer classes to become wage earners; but this is not the case in Bombay where only women of special castes and from certain districts seek employment outside their own homes. It is a common idea that children in Bombay augment family incomes considerably by their earnings, but in 1907 a total of only 3,000 children was employed in factories of all kinds in the City. In 1906 Cotton Mills employed 82,867 males and 29,160 females; the average number at work daily was 100,798; and these 112,027 mill-workers supported 55,539 dependents. In the same year there were 98,519 general labourers on the island, including 20,278 female workers who supported 33,308 dependents; domestic and other service maintained 101,017 persons including dependents; 48,761 persons lived by washing, tailoring, cooking, baking, etc; a total of 113,671 persons obtained their living from trade, by shopkeeping, dealing and hawking; and 54,986 by the carriage of goods or passengers on sea or land.

14. The vast majority of the population of Bombay belong to the working classes, and of these people a very large number exist in a condition of the greatest poverty. Out of the total of 588,713 actual workers present in Bombay in 1906, only 18,849 persons or just over 3·2 per cent. paid income tax, and of these, only 2,192 were in receipt of more than only Rs. 5,000 per annum. Of persons dependent upon salaries only 2,365 received more than Rs. 2,000 per annum and 3,638 received less than 1,250 per annum.

15. *Wages.*—Among workers in Bombay, mill-hands are usually supposed to be exceeding well off, but according to the Bombay Gazetteer the average earnings of workers in the spinning and weaving mills is only Rs. 13 per mensem. Men earn Rs. 14 to Rs. 30 a month, women Rs. 7½ to 9 and children Rs. 5 to 7. The rate of pay of the general labourer varies greatly according to the class of work performed. Coolies employed in heavy work, loading and unloading ships, coaling vessels, etc., may earn as much as from annas 12 to Re. 1 per day; coolies employed on earth work earn from 6 to 8 annas for men and from 4 to 7 annas for women; those engaged in carrying parcels, etc., earn about 5 annas a day. Municipal biggaries receive Rs. 11 a month, male sweepers about Rs. 10 or 11 and female sweepers about Rs. 6. Skilled workmen such as masons and carpenters get an average of about Re. 1 per working day; and smiths, fitters and machinemen from Rs. 20 to Rs. 35 per mensem. Grooms and coachmen generally get about Rs. 12 a month and boatmen and laskars from Rs. 12 to Rs. 15. Domestic servants usually receive either Rs. 3 to Rs. 6 a month and their food or Rs. 9 to 12 without food, but better class servants are paid as much as Rs. 20 and upwards a month. Office peons, chowkidars and messengers usually get from Rs. 10 to Rs. 12 a month and their clothes, and railway porters Rs. 15. Street hawkers of fruit and food usually earn from annas 4 a day up to Rs. 20 a month. The pay of the native clerks and shop assistants varies from Rs. 25 to Rs. 50 and among the more highly paid from Rs. 75 to Rs. 120.

16. *Rent.*—One of the heaviest items of expenditure in the domestic budget of workers in Bombay is house-rent. About 85 per cent. of the population lives in tenements of only one room and among these a large proportion are forced to share their quarters with others. At the Census in 1901, 284,244 people or more than one-third of the total population were found to be sharing rooms with

from 5 to 20 or more other persons and 434,406 lived in single rooms occupied by from 1 to 5 people. The cause of this extraordinary overcrowding is the high rent, which makes it impossible for a large proportion of the wage earning classes to hire a room to themselves; and the majority of these people live huddled together in large buildings composed of one-roomed tenements which are known in Bombay as *chawls*. The average rent of a room in a *chawl* is Rs. 5 a month, but in the more crowded portion of the City such as B. and C. Wards it rises as high as Rs. 6-8 per mensem. In the northern part of the island it averages from Rs. 3 to Rs. 4-4 per mensem.

Comparative statement showing monthly rent of single rooms in chawls.*

	Ward.	1898-1899 Average.	1908-1909 Average.
		Rs.	Rs.
1. Colaba, Fort and Esplanade	A.	3-4	5 10
2. Mándvi, Chakla, Umarkhádi and Dongri ...	B.	3-8	6-8
3. Market, Bhuleshwar and Kumbhárwada, etc. ...	C.	4 8	6-8
4. Girgaum, Walkeshwar and Mahálaxmi ...	D.	3-4	6-0
5. Mazagaon, Byculla, Kámáthipura and Nágpáda ...	E.	2-8	4-4
6. Parel, Sewri and Sion	F.	1-10	3-4
7. Máhim and Worli	G.	1-8	3-0

* Bombay Gazetteer.

In the Bombay Gazetteer it is stated that the rise in rentals since the year 1891 has been ascertained to be not less than 22 per cent. and it has become impossible at present to rent the poorest accommodation suitable for a low-paid clerk and his family, within reasonable distance of the office, at less than Rs. 10 per month. Personal observation has shown that it is not an uncommon thing to find a family, of which the father is earning only Rs. 50 or Rs. 60 per mensem, paying as much as Rs. 25 per month for a tenement of two rooms and a small kitchen. Frequently a number of men of the same class, perhaps 10 or more will rent a room in common and share living expenses, which under these conditions will amount to about Rs. 6 per head per month, or perhaps one man and his wife will take in a number of lodgers. As many as 22 such lodgers have been counted asleep on the floor and adjoining verandah of a single-room tenement rented at Rs. 3-8 per month. Pressure of high rents and consequent overcrowding is responsible for the fact that during the greater part of the year many thousands of people may be seen sleeping out of doors.

17. *Food.*—The lowest estimate of expenditure on food appears to be Rs. 4-8-0 per mensem for a man and about Rs. 3 to Rs. 3-12 for a woman. The majority of adult working males of the labouring class appear to spend from Rs. 5 to Rs. 7 per mensem on food and household expenses, excluding clothes. A number of men of the servant class live in boarding houses, at an inclusive charge of Rs. 10 per mensem. Indian students, nurses, etc., appear to pay an average of about Rs. 13 per mensem for food alone.

The expenditure on food of a family of four, a man, his wife and two small children, was found in one case to be as follows:—

	Rs.	a.	p.
Rent	4	8	0
Tur dal	1	0	0
Rice	8	0	0
Bajri	3	0	0
Ghee	1	0	0
Condiments	1	0	0
Kerosene	0	3	0
Firewood	1	4	0
Toddy	0	8	0
	18	7	0

The man earned Rs. 10 a month as a peon and his wife made *bidlis*.

In another case a widow with five children, two of whom were working and the rest quite small, consumed in the month :—

	Rs.	a.	p.
½ Phara bájri	2	8	0
2 Pharas rice	7	12	0
1 Paili dal	0	6	0
and for firewood, ghee, oil, condiments and miscellaneous expenses ...	7	8	0
	18	2	0

In another case the budget of a family, consisting of a man, a working youth and a young non-working child, was as follows :—

	Rs.	a.	p.
Rice	7	8	0
Flour	1	8	0
Ghee	1	0	0
Dal	0	6	0
Oil	0	6	0
Fuel	1	8	0
Kerosene and matches	0	6	0
Salt	0	2	6

In addition the family spent about Re. 1 per month on tobacco, the man and working youth smoking from 8 to 12 *biddis* a day. The barber was paid 4 annas per head each month, or a total of 12 annas. The total expenditure on necessaries, excluding rent and clothes, was about Rs. 14-8 a month. In this case the man explained that as he could not afford to keep his wife in Bombay she remained at home in her father's house. Occasionally her husband sent her Rs. 5, but to do this he had to borrow and was getting deeper in debt. These figures help to explain the appalling overcrowding in Bombay; for it is clear that when the majority of workers have paid for their food and clothes and the few luxuries in which they indulge, such as tobacco and an occasional drink of toddy or liquor, they have little or nothing left; and under these circumstances they cannot afford to hire a single room to themselves.

18. As the worker in Bombay has to spend a very large proportion of his earnings upon food and fuel it is clear that the fluctuations in the prices of the chief necessaries of life must affect him very greatly; and the larger the number dependent upon the wages of one worker the greater will be the effect of such changes. A single man without encumbrances earning from Rs. 12 to Rs. 15 a month will only spend from one-third to half of his wages on food; and he has a margin of income to prevent him feeling the pinch, as far as the restriction of diet is concerned, should a rise in prices of as much as 25 or 33 per cent. occur; and even if prices were to double there would still be no necessity for him to go short of food. But it is quite otherwise with the labourer on whom a wife and family are dependent. Even at the best of times the vast majority of poorer households in Bombay are only just able to obtain necessary shelter, clothing and food and they are often forced into debt to do this, especially when the purchase of new clothes, the occurrence of a birth or death or some other need arises for expenditure of an unusual nature. In this manner many thousands of the working classes in Bombay, among both casual labourers and those in regular employment, are forced to live from hand to mouth, taking their ordinary meagre diet of rice or bajri when they have money or can borrow and going short from time to time as a matter of course. To these people fluctuations in the market price of food and fuel are of vital importance; and there is no factor which exerts a greater influence upon the health conditions of the masses in Bombay than this question of the cost of food.

But it is probable that the question of high or low prices is not so important as that of fluctuations. If prices are uniform, whether high or low, a population adapts itself to the condition; but fluctuations, especially when they are

considerable, upset the balance for a time. If prices fall, the result on the health conditions of the poorer classes is favourable for a short time; if they rise, and especially if the rise is sudden, the effect upon the health of these classes will be proportionate to the stress produced and will continue until a balance has been struck, either by adaptation to the changed condition or in consequence of prices falling again.

The following table shows the prices during the past 40 years of the four principal food-grains used in Bombay. The table shows the average number of seers (about 2 lbs. avoirdupois) purchasable for one Rupee in each year:—

Year.	Wheat.	Jawár.	Bájri.	Rice.
1871	10·21	16·38	13·21	9·67
1872	10·94	16·12	12·77	10·75
1873	11·64	19·61	16·41	12·61
1874	12·38	22·28	19·49	14·1
1875	11·88	21·09	18·37	11·33
1876	11·64	18·67	15 19	10·79
1877	8·21	10·76	10·78	9·18
1878	6·58	10·25	9·7	8·01
1879	6·93	11·42	10·58	8·54
1880	8·93	16·67	13·72	10·11
1881	10·90	22·38	18·78	12·03
1882	10 37	19 62	16·75	12·41
1883	10·29	18·7	15·85	12·39
1884	11·22	17·41	14·73	11·05
1885 ...	11·38	18·54	14·91	11·14
1886	10·38	17·94	15·07	10 92
1887	9·93	17·77	14·07	10·92
1888	9·6	16·07	13·83	10·78
1889	9·91	16·84	13·14	10·7
1890	10·49	17·38	14·12	11·16
1891	9·7	16·92	14·01	11·11
1892	8·43	13·78	12·68	10·05
1893	9·78	13·41	13·67	7·78
1894	10·95	13·5	14·02	9·63
1895	13·18	14·91	13·94	10·75
1896	11·84	14·74	12·64	10·24
1897	6·66	9·54	8·97	8·45
1898	7·61	13·43	12·94	9·85
1899	7·69	12·4	11·68	9·82
1900	6·06	8·97	8·65	9·01
1901	6·68	13·00	12·21	9·46
1902	7·37	12·61	11·88	8·78
1903	8·12	13·45	14·19	8·33
1904	8·31	13·66	13 49	8·28
1905	8·33	12·85	11·39	8 28
1906	9·44	11·78	11 94	8·27
1907	9·39	12·22	13·23	8·12
1908	6·54	9·83	9·83	6 64
1909	6·86	10·79	10·97	8·30
1910	6·76	11·46	10·79	9·08

In 1865 and 1866 prices of grain rose to an abnormal height in Bombay and did not fall again until after 1870. In 1877, owing to failure of the monsoon, they rose suddenly once more and remained high during the whole of 1878. After this for nearly twenty years they remained comparatively low, but owing to short rains in 1895 and 1896, they rose very suddenly in the last quarter of the latter year and remained high through 1897. In 1900 there was a still greater rise owing to famine in the Presidency, but in 1901 they fell considerably. In the middle of 1907 a very sudden rise took place in the cost of every kind of food in Bombay and of fuel also, and in December prices were far in excess of those at the beginning of the year. The cost of wheat rose 60·1 per cent., jawári, bájri and náchni 37·5 per cent., flour 33·7 per cent., common rice 31·7 per cent., grain and tur dál 20 per cent., cocoanut oil 25 per cent., ghee 20 per cent., and firewood 34 per cent. In 1908 prices still remained high and a still further rise took place in the prices of bájri, náchni, gram and

tur dál. Bájri, which forms the staple food of the Deccani population in Bombay, cost Rs. 2-11-11 per maund during the first five months of 1907, but in September 1908 the price had risen to Rs. 4-4-10, an increase of 56·7 per cent.

As has already been pointed out, although the single man among the workers of Bombay is well off and may be able to save and remit money to his country, the working man with a family has a hard fight at the best of times and a rise in the price of food or in rents affects him very greatly. It is this stress of home life among the working classes which is largely responsible for the appalling mortality among infants and young children in Bombay.

19. *Indebtedness.*—A very large proportion of the population of Bombay, particularly those belonging to the working classes, exist in a chronic state of indebtedness; and of this there are two kinds:—

(*a*) Debts contracted in their country usually in the form of a mortgage on land.

(*b*) Debts contracted locally with Banias and others in Bombay.

Indebtedness of the first class is responsible for bringing large numbers of workers to the City in search of employment. Debts of this nature generally range from Rs. 100 to Rs. 1,000 or more, upon which interest at the rate of from 10 per cent. to 12 per cent. is charged. In many cases holders of indebted land appear to have passed their land on to others, who cultivate it and pay the interest, the original holder retaining nothing but a lien on the land in the hope of some day resuming it.

Local indebtedness is due to another cause. Usually people coming to Bombay in search of work are compelled to borrow from friends or relatives or to obtain goods on credit from Banias. If a man loses his employment, through illness or otherwise, he speedily falls into debt. It is no uncommon thing to find that men earning from Rs. 10 to 12 or Rs. 15 per month are in debt to a Bania for as much as Rs. 50 or more; the crowd of Banias, Márwáries and Cabuli money-lenders who may may be seen hanging round pay offices in Bombay on pay days shows that the petty money-lenders in the City keep a sharp look out upon their clients.

It is often forgotten that, the impelling motive that brings many workers into the City is the necessity for earning money to remit to their homes, either for the support of relations or for the payment of debts or both. Thus it happens that the average Bombay labourer can count upon spending only a portion of his earnings upon himself. It is no uncommon thing for men, who have left their families at home, to remit a considerable amount of their wages each month to their native village. Masons from the Poona District earning Re 1 a day will sometimes send as much as Rs. 15 to their country each month and many workers regularly remit Rs. 5 to 10 at longer intervals. But in many cases they find it necessary to borrow the money which they remit, and as a rule only those without incumbrances in the City, in the form of wife and children, can remit money regularly.

Section 3.

20. MUNICIPAL ADMINISTRATION.—At the head of the Municipal Administration of the City is the Municipal Corporation, the Standing Committee and the Municipal Commissioner. The Municipal Cerporation is composed of 72 members, 36 of whom are elected at Ward Elections by the votes of property-owners and tax-payers. A further 16 are elected by the Justices of the Peace, of whom there are 600 in the City; 2 more are elected by the 110 Fellows of the University; 2 by the Bombay Chamber of Commerce; and 16 are appointed by Government. One-sixth are usually Europeans and one-fourth Pársis and the remainder is mostly made up of Hindus and Mussulmans. A large proportion of the members of the Corporation are holders of University degrees and from 9 to 12 are usually qualified medical men. The Standing Committee is composed of 12 members, 8 of whom are elected by the Municipal Councillors and 4 appointed by Government. The Municipal Commissioner is appointed by Government.

21. With the Municipal Corporation lies the power of the purse, and under the City of Bombay Municipal Act it is incumbent upon it to provide for the execution and maintenance of drainage, water-works, conservancy, reclamation of unhealthy localities, regulation of places for the disposal of the dead, birth and death registration, measures for preventing and checking the spread of disease, maintenance and regulation of markets and slaughter-houses. It has powers also to control public streets, primary schools, vaccination and public hospitals and dispensaries.

22. The entire executive power is vested in the Municipal Commissioner. The Standing Committee acts as a sort of special council to assist both the Municipal Commissioner and the Corporation. When once the works to be undertaken and the services to be rendered are fully determined by the Corporation, the Municipal Commissioner is the sole executive authority under the law for the prosecution and control of such works and services. To assist him in the discharge of these duties the Standing Committee and the Corporation are required by law to place at his disposal four heads of departments, including an Executive Engineer and an Executive Health Officer. Each of these officers is given deputies or assistants as the Standing Committee or Municipal Commissioner may consider desirable.

23. The revenue of the Municipal Corporation is obtained from a general tax on houses and lands, town duties or octroi dues upon grain and flour, sugar, wines and spirits, etc., ghee, timber and firewood ; wheel-tax and tolls, licenses for trades, land conveyances and music; halálkhore service ; water-tax, market receipts, and receipts from Government for liquor licenses and tobacco duty. The total municipal receipts amounted in 1908-1909 to nearly Rs. 1,02,86,000 (£685,733) and the estimated income for 1911 was Rs. 1,20,00,000 (£800,000). The average incidence of taxation per head of the population was Rs. 8-14-11 in 1908-1909 (or very nearly 12*s.*). The total expenditure in 1908-1909 amounted to Rs. 1,06,30,126 (£708,675) or just over Rs. 10-12-0 per head of the population.

24. *Sanitation.*—The Public Health Department of the City is under the control of an Executive Health Officer, assisted by two Assistant Health Officers. One of the latter officers is in charge of conservancy measures and the other superintends sanitary work generally. For administration purposes the City is divided into 7 wards, each of which is in charge of a Deputy Health Officer, who is a qualified medical man. The Deputy Health Officers are responsible both for conservancy and other sanitary work in their respective wards. They are each assisted by a staff of sanitary and conservancy inspectors, assistant inspectors and sub-inspectors.

25. For the purposes of registration of births and deaths and for free medical relief, the City is divided into 10 districts. In each district there is a Registrar, two Sub-Registrars, and one trained visiting Nurse. The Registrars and Sub-Registrars are trained medical men. They have charge of the municipal dispensaries in addition to their own duties, which include the registration of births and deaths, the checking of cemetery returns, enquiry into the cause of death and the disinfection of houses and rooms in which infectious disease has occurred, etc. For this latter work they are provided with a special staff of sub-inspectors, foremen and labourers.

26. The staff of inspectors and subordinates engaged in the sanitary and conservancy work of the City during 1909 was as follows :—

3	Chief Inspectors.	2	Halalkhore inspectors.
7	Sanitary inspectors.	202	Muccadums.
7	Assistant sanitary inspectors.	31	Patels
1	Loading Siding inspector.	6	Trip markers.
1	Night Branch inspector.	4,346	Biggaries.
6	House drain inspectors.	2,863	Halakhores.
68	Sub-inspectors.	1,327	Cartdrivers.

The ordinary disinfecting staff and a special disinfecting staff consisted of 11 sub-inspectors, 1 muccadum and 75 coolies and 4 sub-inspectors, 4 muccadums

and 60 coolies respectively. A special temporary staff was organized during 1909 for anti-mosquito work. It consisted of 10 sub-inspectors and 50 coolies.

27. During 1908-1909 Rs. 24,34,002 was spent on the Public Health Department, Rs. 4,64,535 on Hospitals and Medical Relief and Rs. 2,23,328 on special plague work, or a total Medical and Sanitary expenditure of Rs. 30,91,865. This is equivalent to an expenditure of just over Rs. 3-2-6 per head of the population (about 4*s.* 2½*d.* in sterling). The annual expenditure on the Health Department of the City has averaged over Rs. 20,00,000 during the past ten years. During the sixteen years since the advent of plague in 1896-1897 a total sum of Rs. 70,00,000 has been spent on measures directed against that disease or an average expenditure of about 4½ lakhs or £30,000. The expenditure on anti-plague measures in 1908 amounted to nearly £15,000.

28. The Department of Public Works is under the Executive Engineer, assisted by a large staff of Deputy and Assistant Engineers in charge of different branches of work. Thus there is a Drainage Department in charge of a Special Drainage Engineer and two Assistant Engineers; a Water Department, with two Engineers in charge; a Road Department, controlled by another Engineer; a Streets and Buildings Department, possessing three Engineers; besides several smaller branches in charge of special officers.

The City has spent a total of Rs. 2,82,00,000 upon water-supplies and water works. Large sums have also been spent upon drainage. In the ten years since 1897 57¾ lakhs has been spent on drainage, and it is proposed to carry out further drainage works in the next few years at an estimated cost of 50 lakhs. The expenditure on the Public Works Department of the city has averaged over Rs. 2 ',00,000 per annum during the past five years.

Section 4.

29. VITAL STATISTICS OF BOMBAY.—It is now generally recognized that accurate vital statistics are of great importance to the sanitarian, and in the investigation of any condition bearing upon the health of a community, reliable figures regarding,

(1) total births and deaths;
(2) birth-rates and death-rates;
(3) cause of death, etc.,

may be of great assistance. As is well known, the figures relating to vital occurrences in India generally are not reliable; but in large cities like Bombay and Calcutta, registration though not perfect as regards the recording of births and the causes of death, is fairly accurate as regards the total number of deaths. Years ago Dr. Hewlett, when Health Officer of Bombay, stated that, in his opinion the total number of deaths recorded in that city was accurate, and more recently Dr. Turner, the present Executive Health Officer, has expressed the same opinion.

30. *Annual Mortality.*—The total number of deaths recorded each year since 1848 is as follows:—

1848	..	10,051	1864*	...	25,015	1880	...	21,146	1896*	...	33,451
1849	...	12,828	1865*	...	28,531	1881	...	21,856	1897*	...	47,896
1850	...	15,137	1866	...	16,865	1882	...	20,468	1898*	...	51,961
1851	...	15,980	1867	..	15,500	1883	...	23,530	1899*	...	56,484
1852	...	14,022	1868	...	15,702	1884	...	22,542	1900*	...	79,350
1853	..	13,647	1869	...	17,713	1885	...	21,850	1901*	..	59,495
1854*	...	17,541	1870	..	14,888	1886	...	20,074	1902	...	48,414
1855	...	14,826	1871	...	16,064	1887	...	20,513	1903	...	50,513
1856	...	14,761	1872	...	18,990	1888	..	22,421	1904	...	42,676
1857	...	17,826	1873	...	15665	1889	..	23,378	1905	...	47,762
1858	...	14,312	1874	...	15,496	1890	...	20,534	1906*	...	52,874
1859	...	14,249	1875*	...	18,734	1891	...	23,847	1907	...	38,687
1860	...	14,409	1876*	...	20,873	1892	...	26,518	1908	...	38,271
1861	...	15,014	1877*	...	33,511	1893	...	23,142	1909	...	34,878
1862	...	15,809	1878*	...	26,999	1894	...	27,330	1910	...	
1863*	...	18,696	1879	..	22,527	1895	...	25,081			

* Indicates years in which scarcity or famine existed in parts of the Bombay Presidency.

Increased mortality in the City in these years was probably due to a temporary influx of large numbers of people in excess of the normal.

Examination of this table shows that there has been a general steady increase in the total number of deaths recorded from 1848 to 1896, with certain sharp fluctuations in 1864-1865 and 1877-1878. From 1896 to 1900 there was a sudden rise and then a more gradual fall with slight fluctuations, and from 1907 onwards the total mortality has shown a more sudden drop. Enquiry shows that in the past a sudden rise in the total number of deaths in Bombay City was coincident with the occurrence of scarcity in certain of the rural districts. This was the case in 1854, 1863—1866, 1875 -1878, 1896—1901 and more recently in 1906. At these periods the city population was augmented by large numbers of people seeking employment or relief. The occurrence of acute famine in 1877 and again in 1896—1901 led to the influx of enormous numbers of destitute refugees whose presence served to swell the total mortality to most alarming proportions. Plague was first recognized in 1896 and the epidemic, which broke out that year and every year since, has raised the total mortality of the City considerably.

31. *Seasonal Mortality.*—Until about 16 years ago the deaths occurring in the City were almost equally distributed between the dry and wet seasons, as shown by the following table, but since 1895 an excess of deaths has taken place in the period from December to May.

Year.	Total deaths in year.	Deaths in six months June to November.	Percentage.	Deaths in six months December to May.	Percentage.
1863 ...	18,696	9,649	51·56	9,047	48·39
1864* ...	25,015	10,680	42·69	14,335	57·31
1865* ...	28,631	10,572	36·93	18,059	63·07
1866* ...	16,865	7,002	41·52	9,863	58·48
1867 ...	15,500	7,024	45·32	8,476	54·68
1868 ...	15,702	7,595	48·37	8,107	51·63
1869 ...	17,713	7,963	44·95	9,750	55·04
1870 ...	14,888	7,266	48·80	7,622	51·20
1871 ...	.....	.....	.....	.....	.....
1872 ...	.....	.....	.....	.....	.....
1873 ...	.....	.....	.....	.....	.....
1874 ...	.....	.....	.....	.....	.....
1875 ...	18,734	8,553	45·65	10,181	54·35
1876 ...	20,783	8,707	41·89	12,076	58·11
1877 ...	33,511	15 765	47·04	17,746	52·96
1878 ...	26,999	13,461	49 86	13,538	50·11
1879 ...	22,527	10,832	48·08	11,695	51·92
1880 ...	21,146	9,467	44·77	11,679	55·23
1881 ...	21,856	10,899	49·87	10,957	50·13
1882 ...	20,468	9,368	45·77	11,100	54·23
1883 ...	23,530	11,113	47·23	12,417	52·77
1884 ...	22,542	11,154	49·48	11,388	50·52
1885 ...	21,850	10,551	48·29	11,299	51·51
1886 ...	20,074	9,896	49·30	11,178	50·70
1887 ...	20,513	10,340	50·41	10,173	49·59
1888 ...	.....	.....	.....	.....	.....
1889 ...	23,048	13,250	57·49	9,798	42·51
1890 ...	20,231	9,271	45·83	10,960	54·17
1891 ...	23,501	11,725	49·89	11,776	50·11
1892 ...	26,178	12,280	46 91	13,898	53·09
1893 ...	22,802	11,075	48 57	11,727	51·43
1894 ...	26,908	13,456	50·01	13,452	49·99
1895 ...	24,655	11,413	46·29	13,242	53·71
1896 ...	33,050	15,174	45·91	17,876	54·09
1897 ...	47,475	18,478	38 92	28,997	61·08
1898 ...	51,617	16,642	32·24	34,975	67·76
1899 ...	56,434	16,989	30·10	39,445	69·90
1900 ...	79,350	28,851	36·36	50,499	63·64
1901 ...	59,945	20,365	33·97	39,580	66·03
1902 ...	48,414	17,513	36·17	30,901	63·83
1903 ...	50,513	14,349	28·41	36,164	71·59
1904 ...	42,676	15,859	37·16	26,819	62·84
1905 ...	47,762	14,871	31·14	32,891	68·86
1906 ...	52,874	20,611	38·98	32,263	61·01
1907 ...	38,687	16,422	42 45	22,265	57·55
1908 ...	38,271	15,485	40·39	22,813	59·61
1909 ...	34,878	14,334	41·10	20,544	58·90
1910 ...	34,933	15,914	45·56	19,019	54·44

It might be supposed at first sight that plague which broke out at the end of 1896 was solely responsible for the sudden alteration in the character of the seasonal mortality, but it cannot be entirely ascribed to this cause, as a similar alteration in the character of the seasonal mortality took place in 1864—1866 and again in 1876. In 1863 51 per cent. of deaths were recorded in the period June to December, but two years later, co-incident with an increased mortality totalling nearly 10,000, the deaths occurring in the dry season nearly doubled in number and only 37 per cent. of the total took place in the period June to November. In 1894 only 50 per cent. of the total deaths took place in the dry season, but during 1895 and the following years a rapid increase took place in the deaths recorded at that time of the year, and in 1903 over 70 per cent. of the total deaths took place in that period. Since then there has been a gradual return to normal again and in 1910 over 45 per cent. of the total deaths took place in the period June to November.

32. An examination of the return of male and female deaths for a number of past years supports the view that, co-incident with the advent of plague in Bombay increased migration has taken place, leading to an excess of males in the population and causing a complete alteration in the *ratio* of male to female deaths recorded in the City.

Sex Mortality.—The following table shows the *ratio* of female to male deaths recorded in the City from 1886 to 1909:—

Year	Female deaths to 1,000 male deaths.	Year.	Female deaths to 1,000 male deaths.
1886	931	1898	692
1887	910	1899	693
1888	872	1900	746
1889	892	1901	675
1890	893	1902	737
1891	925	1903	745
1892	951	1904	747
1893	866	1905	763
1894	903	1906	787
1895	855	1907	761
1896	826	1908	768
1897	747	1909	756

It will be noticed that the decrease in the proportion of female to male deaths, which took place in 1896, became greater in subsequent years, the maximum variation being in 1901, the year of the Census. From 1901 until 1906 the *ratio* of female deaths to male gradually increased again, but since that year there has been a slight decline. As a general rule, when dealing with large populations, there is only a slight difference between the death-rates of males and females living under the same conditions; and the only explanation that can be given of the variations shown in the above table is a frequent alteration in the proportion of the two sexes in the population.

33. *Effect of Migration upon Mortality.*—If we were dealing with a permanent population of known number it would be reasonable to assume that an increase or decrease in the total number of deaths occurring from year to year was due either to a greater or a lessened prevalence of disease; and that this in turn was directly related to the climatic, economic or other conditions obtaining at different times. But the factors which determine the variations in the total mortality of large cities in India are usually of a complex nature. In Bombay migration of the population is a factor of tremendous importance both as regards the real and the apparent health conditions of the City. As has already been mentioned, the population of Bombay is augmented each dry season by many thousands of persons most of whom leave the City again before the onset of the south-west monsoon. There are strong grounds for believing that this periodical movement affects at least

15 to 20 per cent. of the population usually present at the time of the Census; and the influence of this migration upon the public health is very marked. But the influx and subsequent exodus of people is not constant from year to year. Scarcity in the Presidency or special demand and high rates for labour in the City results in an abnormal swelling of the population; whereas prosperity in the agricultural districts or lack of employment in the City reduces the periodical migration to a very marked degree; and the result is reflected in the total mortality returns from year to year.

34. It is necessary to discuss the seasonal fluctuation of the population at some length, as very little attention appears to have been paid to it in the past, although it is a factor of enormous importance in relation to the public health problems of the City. The influx of people commences after harvest in November, and their numbers gradually increase throughout the succeeding months until May and June when a sudden exodus occurs.

The Imperial Gazetteer of India speaks of—

> "The almost limitless reserves of the Ghát village whence cultivators "proceed in large numbers to Bombay to work for a few months, and "return with their savings to their villages, either at the Holi festival "(March) or at the commencement of the south-west monsoon."

and states that—

> "The mills in Bombay draw large numbers of labourers from the Kon- "kan Districts of Kolába and Ratnágiri and from Sátára, Poona and Ahmed- "nagar in the Deccan. These for the most part return to their homes "at intervals for such agricultural operations as their continual con- "nection with the land requires."

This movement of the population has continued for a number of years, and some idea of its extent may be gauged by the statements published in the Gazetteers for Ratnágiri, Poona and Sátára Districts, in 1880—1885. The Ratnágiri Gazetteer records under the heading "Movements of the population" the following statement:—

> "It is estimated that in addition to many thousands partly settled "in Bombay over 100,000 workers pass every fair season from Ratnágiri "to Bombay, returning at the beginning of the rains to till their fields."

The Poona District Gazetteer also records that—

> "During the eight months from October to June, especially during "the latter portion of this period, a considerable proportion of the kunbi "or cultivating classes go to Bombay, where they earn a living as palanquin "bearers, carriers, grass-cutters and labourers. It is impossible to make "an accurate estimate of the proportion of the population who yearly "move to Bombay in search of work. It is probably not less than "5 per cent."

The population of Poona District at the period when this Gazetteer was published numbered 900,621.

The Sátára District Gazetteer published about the same time makes a very similar statement regarding the temporary movement of people from that district to Bombay, but gives no estimate of the probable number concerned.

The new Imperial Gazetteer of India published in 1906 states:—

> "The proportion of widowed females to 1,000 widowed males is very "high in Ratnágiri (5,862), Sátára (4,005), Kánara (3,924) and Konkan "(3,794). The plague epidemic in Bombay City to which the male "population of these districts emigrates annually seems to have caused "the death of the husbands."

It would appear from these statements that the City of Bombay nearly 30 years ago was subject to an annually recurring influx of at least 150,000 persons; and there are reasons for believing that the movement has undergone a steady increase during the last fifteen years, owing partly to improved communications, and partly to increased economic pressure in the rural districts.

35. It is the Hindu portion of the population among which the greatest fluctuations take place; and an examination of the following table and curve serves to indicate the extraordinary effect upon the total mortality of the City produced during the past few years by this variation in the population :—

Year.	Deaths among Hindus.	Deaths among Mussulmans.	Deaths among all other classes.
1902 ..	34,729	10,211	3,474
1903 ...	36,709	10,246	3,558
1904 ...	30,246	9,176	3,254
1905 ...	35,010	9,342	3,410
1906 ...	39,106	10,065	3,703
1907 ...	26,847	8,714	3,126
1908 ...	25,725	9,216	3,330
1909 ...	23,332	8,352	3,194
Mean ...	31,463	9,415	3,381

Number of deaths above and below the mean and percentage variation, are shown below :—

Deaths above and below the mean and percentage variation.

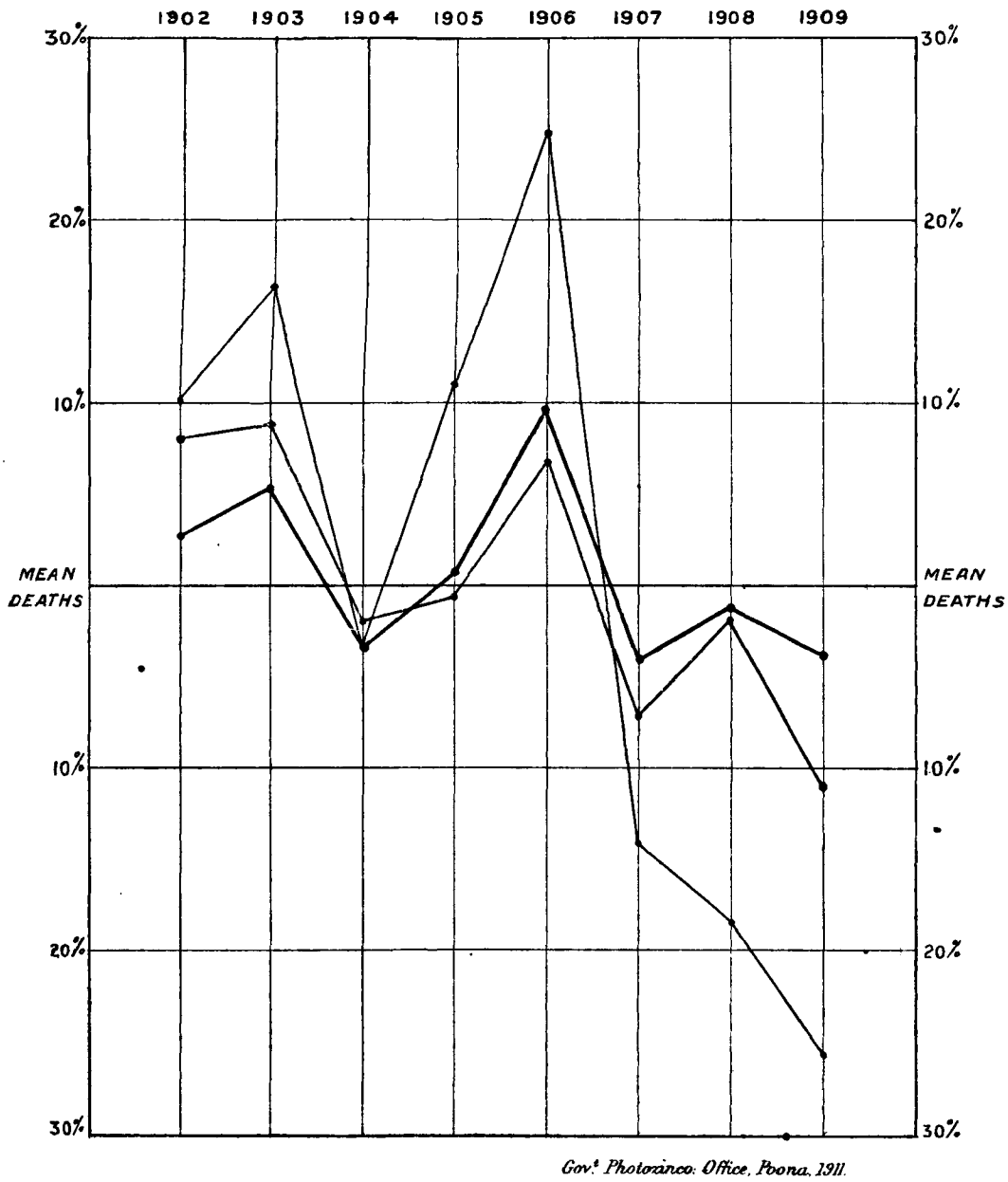
Year.	Hindus.	Mussulmans.	Other classes.
1902	+3,266 = +10·3 per cent.	+796 = + 8·4 per cent.	+ 93 = +2·7 per cent.
1903	+5,246 = +16·6 „	+831 = + 8·8 „	+177 = +5·2 „
1904	−1,217 = − 3·8 „	−239 = − 2·5 „	−127 = −3·7 „
1905	+3,547 = +11·2 „	−73 = − 0·7 „	+ 29 = +0·8 „
1906	+7,643 = +24·2 „	+650 = + 6·9 „	+332 = +9·5 „
1907	−4,616 = −14·6 „	−701 = − 7·4 „	−155 = −4·5 „
1908	−5,738 = −18·2 „	−199 = − 2·1 „	− 51 = −1·5 „
1909	−8,131 = −25·8 „	−1,063 = −11·2 „	−181 = −4·2 „
Mean variation ...	4,925 = 15·6 per cent.	589 = 6·2 per cent.	142 = 4·2 per cent.
Mean variation above the mean ...	4,925 = 15·6 per cent.	759 = 8·0 per cent.	155 = 4·5 per cent.
Mean variation below the mean ...	4,925 = 15·6 per cent.	455 = 4·8 per cent.	128 = 3·7 per cent.

The mean population of Hindus during the 8 years was probably about 500,000, that of Mussulmans about 150,000 and of other classes about 90,000. The latter class, which includes Parsis, Native Christians, Europeans and Eurasians, is probably less liable to great fluctuations than either Hindus or Mussulmans; and the difference between the mean variations in the annual mortality among Hindus and members of this class indicates the probable fluctuation of mortality due to excessive or reduced migration. In the dry season of 1906 the Hindu population was probably swollen to a figure 10 to 15 per cent. above the average dry weather population and in 1908 and 1909 it was from 15 to 20 per cent. below it. From 60 to 80 per cent. of the apparent improvement in mortality during the past few years is probably due to diminished migration from the rural districts owing to better monsoons and increased prosperity.

36. *Death-rates.*—Total mortality figures give but a slight indication of the true state of the public health and it is usual for comparative purposes to make use of death-rates, that is the ratio of persons dying each year to the total population living. For calculating death-rates it is necessary to have an estimate of the total population, and the figures obtained at each decennial census are made use of for this purpose.

In Great Britain it is customary to calculate the population living in each year of the inter-censal periods and to base birth and death-rates upon these figures; but in India no such correction is made, birth and death-rates being calculated upon the census population.

CURVES SHOWING THAT LARGE VARIATIONS IN MORTALITY IN BOMBAY ARE PROBABLY DUE TO INCREASED OR LESSENED MIGRATION OF HINDUS.



Gov.t Photozinco. Office, Poona. 1911.

——— Deaths among Hindus.

——— Deaths among Mussalmans.

——— Deaths among other Classes.

The following table shows the population of Bombay as found in different Census years :—

Year.	Male.	Female.	Females to 1,000 males.	Total.
1872	399,716	244,689	612	644,405
1881	464,763	308,433	664	773,196
1891	518,093	303,671	586	821,176
1901	479,786	296,220	617	776,006
1906	612,965	364,811	595	977,822

The death-rates calculated upon these populations have been as follows :—

Year.	Population of the City of Bombay.	Total deaths.	Percentage.
1872	644,405, Census 1872 ...	18,990	29·46
1873		15,665	24·30
1874		15,496	24·04
1875		18,734	29·07
1876		20,783	32·25
1877		33,511	52·00
1878		26,999	41·90
1879		22,527	34·96
1880		21,146	32·81
1881	773,196, Census 1881 ...	21,856	28·27
1882		20,468	26·47
1883		23,530	30·43
1884		22,544	29·15
1885		21,850	28·26
1886		20,074	25·96
1887		20,513	26·53
1888		22,421	29·00
1889		23,378	30·24
1890		20,534	26·56
1891	821,764, Census 1891 ...	23,847	29·01
1892		26,518	32·26
1893		23,142	28·16
1894		27,330	32·25
1895		25,081	30·52
1896		33,451	40·81
1897		47,896	58·28
1898		51,961	63·23
1899		56,434	68·67
1900		79,350	96·56
1901	776,006, Census 1901 ...	59,195	77·36
1902		48,414	62·38
1903		50,513	65·39
1904		42,676	54·99
1905		47,712	61·48
1906	977,822, Census 1906 ..	52,874	53·07
1907		38,627	39·56
1908		38,271	39·13
1909		34,578	35·66
1910		34,933	35·71

37. But the results obtained by attempting to calculate death-rates upon the census figures in Bombay are practically worthless for the following reasons :—

(1) It is an exceedingly difficult thing to obtain an accurate census in Bombay.

(2) The census is usually conducted in the middle of the dry weather when the yearly influx of people is at its height; and the number present then is far in excess of those to be found a few months later. The mean of the population present in the City during the dry and the wet seasons is probably not less than 100,000 below the census population.

(3) Owing to the fact that the influx of people into Bombay is not constant from year to year the census may show a population either greatly in excess of the average yearly dry weather population or greatly below it The 1901 census population was supposed to be much below the normal the 1906 census was certainly greatly in excess of the normal.

38. *Census population and actual population.*—The census of 1906 was taken on February 9th at a time when the population of Bombay was swollen by an influx of destitute famine refugees and an army of workers in excess of the number usually finding employment there, and it was recognized at the time that an abnormal influx of people had occurred. The Administration Report of the City for 1906-1907 speaks of the deficient rainfall of 1905 and remarks—

"As usual, the influx of famine refugees proved to be one of the "principal causes of the increased unhealthiness of the City.....".

Many important works also were undergoing construction during this year. and served to attract an abnormal number of labourers to the City.

The Executive Health Officer records in his report for 1906 that—

"Electric tram-lines are under construction which has brought to "the City a large number of labouring hands, to add to the number already "engaged in the construction of the Docks. A large number of labourers "is also employed for the construction of the Harbour Railway of the "Port Trust. In this way there is a floating population of about 50,000 in "addition to the standing population."

A specially large number of women was present in the City that year, as shown by the increase in the total female deaths, which rose 3,000 in excess of the mean of the previous four years. The total number of registered births also reached the highest figure ever recorded.

The number of mill-hands resident in the City had also shown an increase. The average daily number of mill-hands employed in Cotton Mills since 1901 is as follows:—

1901	...	...	82,162
1902	...	...	86,122
1903	...	...	96,913
1904	...	...	89,915
1905	...	...	92,924
1906	...	...	100,798
1907	...	...	98,101
1908	...	...	101,536

39. All these facts point to the presence of a specially large population in 1906; but there are grave reasons for doubting the accuracy of the special census held in that year. In 1901 the census, which was carried out in March, showed a ratio of females to males of 617, and the death returns during the months of January, February and March 1901 show a *ratio* of female deaths to male of 590, 598 and 604 rising to 691 in April. It is apparent therefore that there was a close relationship between the proportion of females to males as ascertained by the census and that inferred from the relative mortality of the two sexes about the census period. But the 1906 census, which was carried out in February, gave a *ratio* of only 595 females to 1,000 males, though the mortality returns show that in January, February and March respectively, 802, 737 and 712 females died to every 1,000 males. This lack of correspondence between, the *ratio* of female to male deaths and that of living females to living males, as found by the census, indicates a serious error in the enumeration. If we assume that the female population was accurately enumerated, there appears to be a discrepancy in the number of males, the total of 612,965 found by the census being at least 100,000 in excess of the number actually present in the City. Such an error might easily occur by failure on the part of the enumerators to cancel names of absentees at the final enumeration.

40. Fortunately there are means which enable us to find out whether the mean population of the City varies to the extent the census figures show.

If there had been an increase of more than 25 per cent. in the population of 1901 in 1906, there should have been a corresponding increase in the consumption of food, etc., in the City. If we examine the figures in the Administration Reports of the City we find that the amounts of grain and other foodstuffs consumed in Bombay, as shown by the amounts that paid octroi dues in the years 1899 to 1909, was as follows:—

Year.	Candies of Grain.	Maunds of Ghee.	Candies of Firewood.
1899	14,85,140	3,52,392	6,47,470
1900	6,95,271	3,30,744	5,66,262
1901	10,65,640	3,24,243	6,74,552
1902	10,41,474	3,34,745	5,56,060
1903	9,49,052	3,53,018	5,77,070
1904	10,95,010	3,66,895	5,89,196
1905	9,33,513	3,91,157	5,82,525
1906	10,34,788	3,88,371	5,78,700
1907	10,15,669	4,05,287	... ...
1908	11,74,695	4,02,793	.....
1909	9,72,280	3,92,288	.. ...

The figures given above refer to the net amount of goods paying town dues and as such are supposed to represent local stock and consumption. It may be remarked that since 1901 there has been a great increase in the number of buffaloes, bullocks and horses in the City, all consuming a considerable amount of grain, and tending to swell the total of grain consumed each year. In 1904 also arrangements were made to impose a special check upon the quantities of goods paying town dues, as fraud had been detected in the claims for rebate on exportation.

Further evidence is supplied by an examination of the figures which shew the number of animals slaughtered in the municipal slaughter-houses each year for food. These figures of course relate only to food consumed by the flesh-eating portion of the population and they are liable to be influenced very greatly by increased prosperity, higher wages leading to an increased consumption of meat. The figures given below show that there has been only a moderate increase since 1901.

Year.	Buffaloes, Cows Bullocks and Calves.	Sheeps and Goats.	Pigs.
1900	43,547	603,208	656
1901	44,388	578,861	649
1902	42,157	616,295	680
1903	38,793	624,341	654
1904	41,908	616,634	599
1905	48,483	650,289	628
1906	47,834	674,191	641
1907	47,304	669,014	631
1908	49,253	653,372	568
1909	48,665	633,057	563

In addition to these facts the census of 1906 only showed an increase of about 10 per cent. in the number of inhabited houses in the City as compared with 1901. Taking everything into consideration there does not appear to have been such an extraordinary variation in the mean annual population during the past ten years, as that shown by a comparison of the census returns of 1901 and 1906.

41. Unfortunately it is impossible to say whether the mean annual population of Bombay amounts to 700,000 or to 900,000 and unless measures were adopted for keeping an accurate record of all those who enter and leave the island, so as to correct the estimate of the population from time to time, it is difficult to see how a definite standard is to be obtained. Many years ago the

suggestion was made that, a double census should be held, one enumeration in the dry weather and another in the rains, but this would of course only give figures for one year, which might be completely upset the following season.

In view of these facts it has been considered wise to attach no weight to conclusions based upon the mortality rates of Bombay.

42. *Errors in death-rates.*—But the error in calculating death-rates upon an unknown and fluctuating population is still further increased by the fact that the crude death-rate takes no account of the number of sick people who leave Bombay and die in other places; and also that in calculating the crude death-rate no allowance is made for the age and sex distribution of the population. It is a well known fact that persons of different ages die at different rates, mortality being very high among young children, low among young adults and high again among the old people. There are also slight differences in the death-rates of the different sexes, but these are not so great in India as to be important. Towns usually contain an excess of young adults whose death-rate is less than that of the general population; and as a result the recorded death-rate of towns is usually too low.

43. Various methods have been devised for correcting the errors in death-rates arising from sex and age constitution of a population. The method most generally used in England is based primarily upon the actual death-rate of each sex at different ages throughout England and Wales. In use a hypothetical death-rate is calculated for each large city, based on the number of deaths that would have occurred in any given year if the population existing in the city at different age periods had died at the same rates as persons of the same age in the country as a whole. This hypothetical death-rate is called the standard death-rate. The correction factor is obtained by dividing the actual number of deaths in the year with the hypothetical total obtained under the standard death-rate.

If we wish to compare the mortality rates of Bombay with those of the whole Presidency, we must make a somewhat similar correction, and we find that the standard death-rates for Bombay for the years 1907, 1908 and 1909 calculated on the assumption that the City population at various age periods died each year at the same rate as those of the same age in the whole Presidency were:—

1907	...	...	...	...	28·1 per 1,000
1908	...	...	...	...	22·4 „ „
1909	...	...	...	...	22·9 „ „

The total number of deaths that would have occurred at these rates (on the basis of the 1906 census) was—

1907	...	...	...	...	27,555
1908	...	...	...	...	21,980
1909	...	...	...	...	22,208

And the actual number of deaths occurring each year divided by these figures gives the correction factors of—

1·403 for 1907
1·741 for 1908
1·563 for 1909

When corrected by means of these factors the death-rate for the City for the three years becomes—

	1907.	1908.	1909.
Crude death-rate as recorded in Bombay	39·56	39·13	35·66
Death-rate corrected for age distribution of population	55·50	68·12	55·84

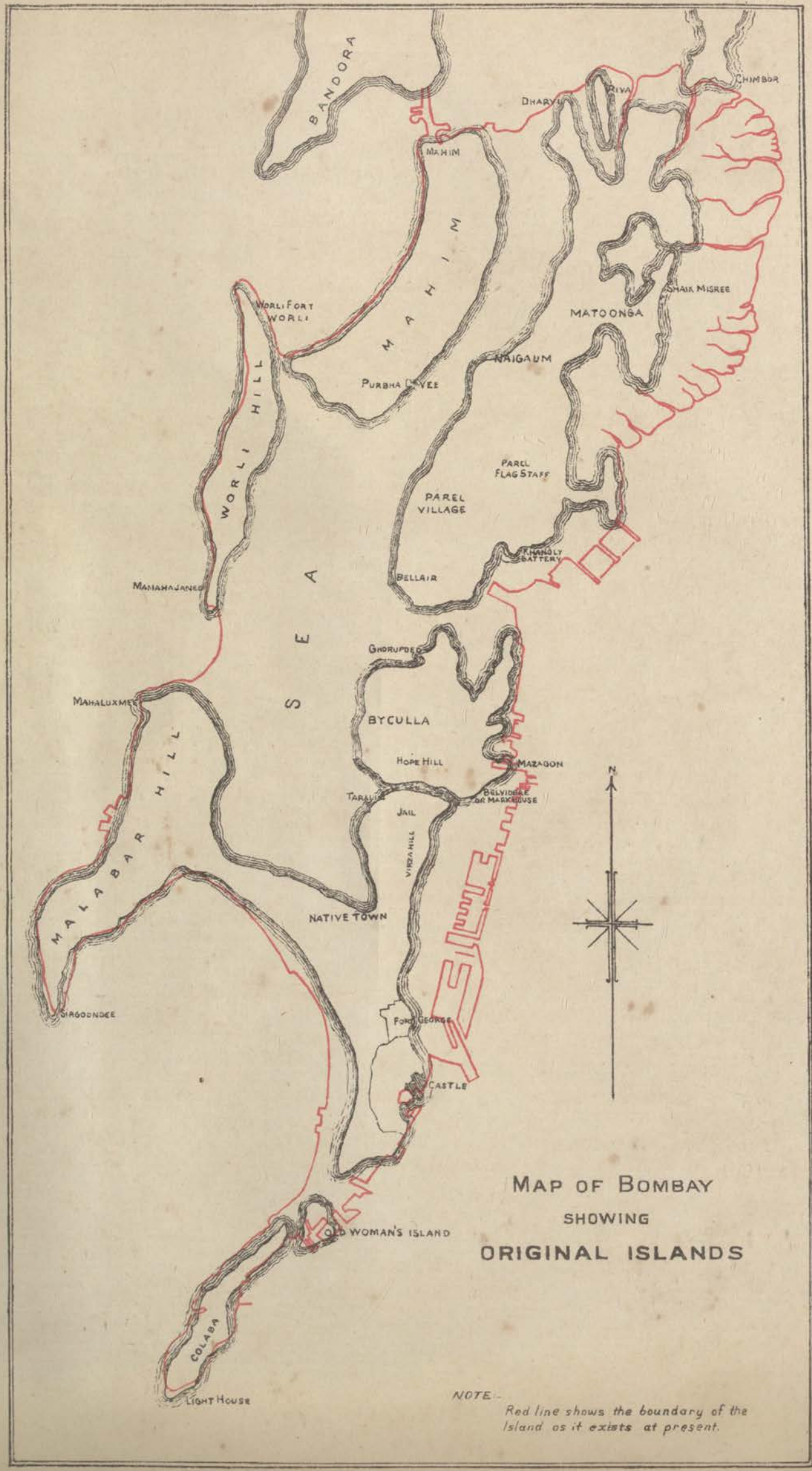
These figures are not put forward as being accurate, as neither the census figures for the Presidency nor those for the City are correct, but they serve to indicate the fallacy of basing conclusions regarding the health of Bombay

upon the figures of a crude death-rate. As a matter of fact 1908 was undoubtedly more unhealthy than 1907, owing to the prevalance of malaria, but this was absolutely masked by the uncorrected death-rates for these years.

44. *The causes of death in Bombay.*—As has already been pointed out the registration of causes of death in Bombay is largely a matter of guess-work. In 1909, 21 per cent. of deaths were certified against 7 per cent in 1901, but in the vast majority of cases, dependence has to be placed upon enquiries made of friends or relations. In 1910, 8,394 deaths were certified and 19,607 verified by enquiry among friends and relatives of the deceased. This latter work is carried out by a special registration staff first appointed in 1902. One effect of this improved organization was the immediate reduction of the number of deaths recorded under the head fever, a reduction which might be ascribed to other causes if this co-incident alteration in the method of registration were overlooked. Unfortunately in the published returns certified causes of deaths are pooled with those arrived at as the result of enquiry after death.

45. The principal causes of death, as at present recorded, are plague, cholera, small-pox, fevers, dysentery, diarrhœa, phthisis and respiratory diseases. The following table gives the total deaths recorded under different headings, taken from the Annual Report of the Executive Health Officer for the City. The rate per 1,000 of the population is not given, as in view of the uncertainty regarding the actual population at any given period such figures are fallacious :—

Year.	Small-pox.	Measles.	Fevers (including Sarlet, Enteric, Malaria, Ague, Remittent, and Relapsing).	Cholera.	Plague.	Phthisis.	Diseas. of the Nervous system.	Disease of the Respiratory system.	Diarrhœa.	Dysentery.	Accidents.	All other cases (except still-born).
1901 ...	159	67	7,921	198	18,736	6,516	2,971	7,804	2,375	1,341	764	10,643
1902 ...	288	642	4,518	75	13,820	3,957	3,027	7,250	2,206	1,377	732	10,462
1903 ...	1,477	1 115	2,333	17	20,788	2,842	2,282	7,101	1,757	1,003	547	9,251
1904 ...	568	229	2,530	219	3,538	2,971	2,412	7,339	1,863	921	558	9,042
1905 ...	2,161	620	2,878	26	14,198	2,55[illegible]	2,026	9,103	2,402	989	646	10,175
1906 ...	276	936	4,882	1,241	10,823	3,569	2,085	11,731	3,264	1,514	714	11,841
1907 ...	86	197	3,633	439	6,389	2,877	1,803	9,022	2,348	1,141	813	9,969
1908 ...	1,025	653	3,403	95	5,361	2,387	2,083	8,954	2 007	1,177	808	10,317
1909 ...	473	75	2,800	727	5,197	2,415	2 143	7,974	1,592	933	698	9,791
1910 ...	1,608	184	3,113	107	3,656	2,282	2 005	8,214	2,155	1,197	9,830	
Mean ...	812	462	3,801	314	11,250	3,237	2,289	8,449	2,282	1,159	.....	



MAP OF BOMBAY
SHOWING
ORIGINAL ISLANDS

NOTE -
Red line shows the boundary of the Island as it exists at present.

Gov^t Photozinco. Office, Poona. 1911.

PART II.—MALARIA IN BOMBAY.

CHAPTER I.

THE HISTORY OF MALARIA IN BOMBAY.

46. Bombay has passed through many periods of ill-health, from the time when speaking of Europeans it was said that, "Two monsoons were the life of a man" to the more recent outbreak of plague, but there are few references to malaria to be found in the history of the Island and this fact supports the assumption that the City has never suffered as severely from malaria as many other parts of India.

Freyer writing of Bombay in 1673 remarks :—

> "I reckon the people of Bombay walk in charnel houses, the climate "being extremely unhealthy, as first thought to be caused by bubsho, "rotten fish; but, though that be prohibited, yet it continues as mortal. "I rather impute it to the situation which causes an infecundity in the "earth, and a putridness in the air, which being produced seldom coming "to maturity, whereby what is eaten is undigested; whence follow fluxes, "dropsy, scurvy, barbiers, gout, stone, malignant and putrid fevers, which "are endemial diseases."

And Aungier, the famous Governor of the Island, in a report written in the same year as Freyer's memoir, stated that—

> "After the first intermission of the rains in May or June and after "their total ceasing in October the air and water are unwholesome by "reason of the crude pestiferous vapours exhaled by the violent heat of the "sun into the air and vermin created in the wells and tanks which renders "those months mostly sickly to the inhabitants, and especially Europeans."

A few years later Ovington writes of Bombay as follows :—

> "Fish manure is a mortal enemy to the lives of Europeans. We "arrived here at the beginning of the rains and buried of the 24 passen- "gers we brought with us above 20, before they were ended; and of all "our own ships' company above 15. ..... The prodigious growth "of vermin and of venomous creatures at the time of the monsoons do "abundantly demonstrate the malignant corruption of the air."

47. In recent years it has been suggested that malaria was responsible for the condition of things recorded by Freyer, Aungier and Ovington.

Campbell in his History of Bombay (Vol. I, p. 437), remarks :—

> "Various causes were assigned for the alarming mortality amongst "Europeans in Bombay. The atmosphere was at first supposed to be "polluted by the putrid fish with which the trees were manured. A more "reasonable conjecture was that malaria arose from the low plains "which were overflowed at high tides and left in a swampy state when "the sea receded."

And in the recently published Bombay Gazetteer, a comment upon Aungier's report suggests that :—

> "One of the chief reasons for the unhealthiness recorded by him, was "doubtless the gradual silting-up of the creeks which divided Bombay into "a group of islets. At high tide the sea swept through the breaches, "overflowed the major portion of the island, and left a pestilential deposit "highly productive of malaria; and the conviction of the truth of this "suggestion led the Court of Directors between 1684 to 1710 to constantly "emphasize the need of stopping up the breaches and reclaiming the "drowned lands."

48. Bombay appears to have become more healthy, after Aungier's time.

Grose writes in 1750 as follows :—

"Whatever may be the reason the point is certain that the climate is "no longer so fatal to the English inhabitants as it used to be, and is "incomparably more healthy than that of many other of our settlements. "The most common disorders are fever, bloody fluxes, cutaneous eruptions "and a sort of tetter called ringworms."

And he points out that, one reason assigned for the island having grown healthier, was the lessening of the waters, by a breach of the sea being banked off.

But he adds—

"This however does not seem to me a satisfactory reason. There is "still subsisting a great body of salt-water in the inside of the breach, the "communication of which with the sea being less free than before the "breach was built must be in the proportion more apt to stagnate and "breed noxious vapours. The improvement is due therefore more to "different diet and manner of living of the Europeans and also to the "place being provided with more skilful physicians than formerly."

49. A few years later, in 1757, a serious epidemic broke out both among the labourers employed on the fortifications and the general population of the City. Of the exact nature of this epidemic there is no evidence, but it is quite possible that it may have been malaria.

It is recorded in 1774 among certain details regarding hospital administration that, "In the General Hospital during the month of January 1774 the number of sick was 3,368, and of these cases 156 were fever." In the Convalescent Hospital during the same month there were 2,372 sick, of whom 434 were cases of "intermitting fever."

In 1787 the Polish traveller Dr. Hēve refers to a statement of Dr. Scott, who, he says, informed him that—

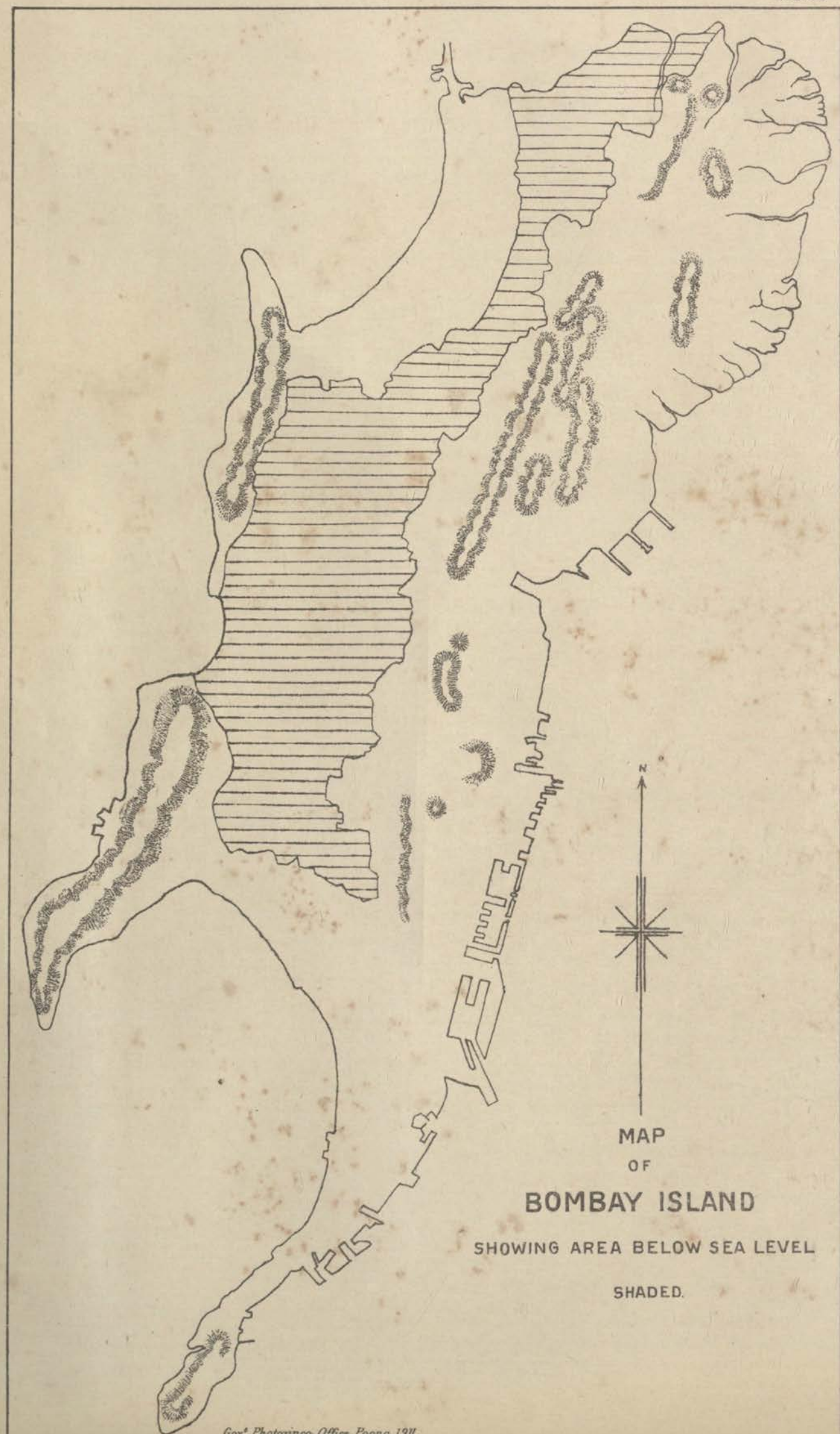
"The people of Mahim often manure their plantations with "putrified fish, which renders the air unwholesome to those that live in "it. Not an instance is known of an European recovering of a fever if he "has contracted it in these woods."

What this Mahim fever really was we do not know, but for many years this part of Bombay was supposed to be intensely malarious and people still cling to this idea at the present time.

50. The records regarding the condition of Bombay during the early part of the 19th Century are rather contradictory. Captain Seely, who was in Bombay in 1825, remarked that—

"The climate of Bombay is preferable to most parts of India, having "a refreshing sea-breeze commonly called from its healthful effects the "'Doctor'. There is now very little wood on the island, no marshes, and "but few large pools of stagnant water. To these causes much of the "sickness that prevails in other parts of India must be attributed and "the salubriety of Bombay causes it to be resorted to by invalids from "other Presidencies and the interior."

But reference to the Diary of Lady West, written about the same time (1825—29), leads to a different impression ; for this authoress frequently mentions the extreme unhealthiness of Bombay and records a number of cases of illness and death among her friends and acquaintances. Her house was in the Fort and it is interesting to note the bitter complaints she makes regarding the prevalence of mosquitoes there. Among other items she records the fact that one of the Crown Judges, who was sent out from England to assist her husband, was taken ill with "fever" in her house, within three weeks of his arrival in Bombay. Apparently the Judge, his wife and her maid were all prostrated at the same time. These facts hardly support Captain Seely's eulogy of Bombay.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MAP
OF
BOMBAY ISLAND
SHOWING AREA BELOW SEA LEVEL
SHADED.
Gov.t Photozinco Office, Poona, 1911.

51. In 1838 an anonymous writer in the Asiatic Society's Journal in a description of the island of Bombay, remarks that—

> "The island of Bombay from an unwholesome swamp has been converted into a very salubrious residence.....the superabundant trees have been cut down, the marshes filled up....."

That the writer connected the improvement in the health of Bombay with the filling up of the swamps is certain, but in view of the fact that a great portion of the island at the present day is still below sea-level and must have been subject then as now to flooding and the formation of large numbers of pools of stagnant water, this explanation is doubtful; and from what we learn a few years later it may be questioned whether there was much reason to suppose that such a change as that recorded by the writer had been effected. Thus between 1840—1850 we learn that there were terrible miasmata in the Fort and Esplanade. And Douglas in "Glimpses of Old Bombay," page 39, speaking of Colaba, says—

> "The suspicion that it was unhealthy in the year which followed, took tangible shape in 1840, when it was announced to the dismay of all concerned, that Colaba having been pronounced by medical authorities a most unhealthy station for European troops is to be forthwith abandoned as a military station.....And in 1841 a Medical Board found that a deadly malaria was caused by the mangrove trees on the western shore and the sea washing thereon twice in twenty-four hours."

The writer adds—

> "Colaba would soon have justified its name of Old Woman's Island had not the two Napiers Charles and Robert stepped in successively to avert this disaster. The spade and the blade were the remedies."

Some years later Dr. Hewlett speaking of Bombay prior to 1835 stated that "the City had an unenviable reputation for unhealthiness" and in 1874 the Health Officer of the City refers to "*the putrid salt marsh to the windward of the town,* undrained, uncared for,.....horribly offensive, unutterably foul.....*" and remarked that this condition had remained unabated for thirty years.

52. Although such evidence as exists does not point to malaria having been particularly prevalent in Bombay, it is certain that the disease must have been present to some extent even in the earliest times. And this view is borne out by facts gleaned from later records. Thus Morehead in speaking of the type of malaria met with in different parts of India mentions that of 243 cases in Bombay, 221 were quotidian, 27 tertian and 5 uncertain. At a later date Vandyke Carter working in Bombay was the first medical man in India to confirm Laveran's discovery of the malaria parasite. Carter records finding Laveran's organism present in 13 per cent. of the cases examined by him, so that malarial infection was undoubtedly present to an appreciable extent at that time; and as Carter only noted the presence of pigmented organisms it is probable that a much larger proportion of his cases were malarial in nature than his figures show. Unfortunately few recorded observations relating to the incidence of malaria in Bombay since Carter's time appear to exist; and though in 1901 in a special report regarding malaria and anopheles mosquitoes it was asserted that, until the public generally were educated to appreciate the fact that malarial fevers were the cause of most of the sickness in the City, little could be done to reduce the disease, no evidence regarding the prevalence of the disease, or its local incidence, appears in the report.

53. In 1901 a Committee of eleven members of the Corporation was appointed to deal with the question of the presence of anopheles mosquitoes in the City and the measures to be adopted against them. Their report was submitted to the Corporation in 1902. No investigation regarding the presence of malaria was undertaken, but the Committee recommended that steps should be taken to destroy all kinds of mosquitoes.

54. The only information available regarding the incidence of malaria among the population before 1903 is in the form of mortality returns and statistics of admissions to hospitals and dispensaries; but in that year a valuable paper

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* The italics are mine.—C. A. B.

was read before the Bombay Medical and Physical Society by Dr. S. A. Powell, the Police Surgeon; and this paper gives some idea of the actual incidence of malaria among a portion of the population during the period 1901—1903. Dr. Powell as the result of the microscopic examinations of the blood of 3,413 cases of fever, chiefly met with among the Police of the City, diagnosed the presence of malaria parasites in 2,542.

55. It is difficult to find any record of much value regarding malaria in Bombay from the date of publication of Dr. Powell's paper until the end of 1908. In a recent report published by the Health Department references are made to the occurrence of the disease at Chowpati, and in the neighbourhood of the Malabar Hill Reservoir in 1905. It is also recorded that in 1906 a request to be allowed to examine the blood of children in 10 schools at Mazagaon, in order to ascertain the prevalence of malaria, was refused by those in charge, except in two cases.

56. In September 1905 the Municipal Corporation passed the following resolution :—

> "That in view of the steadily increasing prevalence of malarial and "various other fevers in the City, and the very high rate of mortality "resulting therefrom for several years past, it is very necessary in the "opinion of this Corporation, that a comprehensive and searching enquiry "should be instituted with regard to their causation and spread and "the measures necessary for their prevention and removal so far as "is practicable."

As a result of this resolution a Committee was appointed to enquire into certain matters connected with the prevalence and causation of malarial and other fevers in Bombay City; but no actual investigation of the disease was undertaken and the Committee after sitting for about two years published a report in 1908, in which little mention is made of malaria.

57. But towards the end of 1907 complaints began to be made about malaria in the neighbourhood of the Frere Road and the Corporation passed a resolution in December 1907 asking the Municipal Commissioner to report as to the cause of an epidemic of virulent type which had broken out there. In December 1907 Dr. Cogill called attention to the fact that among 200 of the Governor's Body Guard, resident in the lines at Chowpati, there had been 40 cases of malaria, and stated that the disease was steadily increasing. The Body Guard lines are situated at the base of Malabar Hill and leakage from the reservoir above them formed small pools and streamlets in which anopheles mosquitoes were readily found.

58. In May 1908 certain residents in the Frere Road addressed a letter to the Municipal Commissioner making further complaints regarding malaria in that locality. In this letter they stated that some of them had lived in that neighbourhood for ten years without suffering from malaria until the construction of the New Docks was undertaken there. The contract for the New Docks was signed in April 1904, work began the same year and the foundation stone was laid in 1905, but the earliest complaints about malaria in the vicinity appear to have been submitted late in 1907, three clear years after the work had commenced.

59. During 1908 numerous complaints of malaria were made from many parts of the City, but there is no definite information regarding the incidence of the disease in any locality with the exception of that given in a valuable paper by Major Liston, I. M. S., published in the Journal of the Bombay Natural History Society, November 1908. In this paper Major Liston records the fact that an investigation in the neighbourhood of the Frere Road adjoining the New Docks had shown that 80 per cent. of the children resident there had enlarged spleens and 50 per cent. of those examined by him harboured malarial parasites in their blood. Two species of anopheles mosquitoes were caught by him in the locality, *Nysso-Myzomyia rossi and Neocellia stephensi* and the dissection of a number of the latter led to the important discovery that 25 per cent. were infected with malaria.

60. In November 1908 the Government of Bombay influenced by the serious nature of the epidemic of malaria in the City, decided to take action and to arrange for a systematic investigation of the causes which had led to the outbreak with a view to the adoption of preventive measures in the future.

CHAPTER II.

61. THE MEASUREMENT OF MALARIA IN BOMBAY.—In discussing the prevention of malaria in a community, Ross has laid down as one of the first essentials the necessity for a careful measurement of the malaria present; and he has pointed out that for this purpose direct observation is of greater value than inferences drawn from hospital statistics and mortality returns. Before the present investigation no serious attempt appears to have been made to measure the amount of malaria in Bombay, but a few isolated enquiries have been made from time to time in different parts of the City.

In Bombay with rare exceptions the microscope is not greatly used in the diagnosis of malaria. The report of the Municipal Analyst shows that the following numbers of blood specimens have been examined for malaria in the municipal laboratory since 1904, but the results are not given :—

Numbers of blood specimens examined for malaria—

1904	8
1905	3
1906	2
1907	12
1908	166
1909	80

As will be seen the number is too small to be of much value as a test of the incidence of malaria in the City.

62. The most valuable information available regarding the incidence of malaria in the past is to be found in a paper by Dr. S. A. Powell, previously referred to, which deals with the occurrence of malaria in 1901 to 1903, as diagnosed by the microscope, chiefly among the Police. The City Police, who are stationed in every part of the island and live in different localities, numbered about 2,000 in 1901—1903. They are picked men as regards physique, they have steady employment, good clothing and shelter, and they receive regular medical attention. During a succession of years 1901—1903 an average of nearly 1,000 admissions for malaria or just about 500 per 1,000 of strength occurred amongst these men, and we are justified in assuming that the incidence of the disease among the general population of Bombay in those years was not less than this.

Dr. Powell's paper shows that taking two complete years together the number of cases of malaria in the first half of the year was 790 and in the second half 1,425, and the number in each quarter was 385, 405, 648 and 777 respectively. Below is a table extracted from Dr. Powell's paper, which shows the monthly incidence of malaria :—

	1901.	1902.	1903.
January	...	63	83
February	...	57	53
March	...	64	53
April	44	75	84
May	47	71	64
June	46	94	51
July	94	106	108
August	114	110	108
September	...	119	83
October	111	150	...
November	130	145	...
December	96	119	..

Of the total 2,542 cases, 1,186 showed Malignant Tertian, 1,382 Benign Tertian and 41 Quartan parasites. None of the cases died—a fact which confirms the generally recognized amenability of malaria to adequate treatment by quinine.

Dr. Powell has kindly supplied me with particulars of a further 611 cases of malarial infection met with by him between September 1903 and April 1904. Of these 393 were Malignant Tertian, 209 Benign Tertian and 11 Quartan.

The monthly incidence of infection was as follows:—

1903.		1904.	
September ...	... 34	January ...	... 115
October ...	... 83	February ...	... 45
November ...	... 120	March ...	... 56
December ...	... 92	April ...	... 66

63. In a recent report the Executive Health Officer records the fact that in 1906 letters were addressed to those in charge of the ten schools in the Mazagaon area asking permission to examine the blood of the scholars with a view to ascertain the prevalence of malaria in the neighbourhood of the Bhandarwada Reservoir. Most of these requests were refused, but in March 1906 microscopical examination was made of specimens of blood taken from the children of two of the institutions, with the following results:—

	Number examined.	Number infected.	Percentage infected.
St. Joseph's Home and Foundling Hospital ...	25	15	60·00
St. Peter's Boys School	28	15	53·37

In December 1907 owing to complaints regarding malaria at the Governor's Body Guard Lines, an investigation of the area was made and a few specimens of blood were examined with the following results:—

No.	Name.	Clinical features.	Remarks. Examination of blood films.
1	Lance-Duffadar Fatteh Mahomed Khan.	Enlarged spleen, suffering from fever of tertian type.	Malarial parasites.
2	Sowar Met Sing ...	Chronic enlarged spleen, suffers from fever occasionally.	Malarial parasites, a large number of eosinophilis.
3	Lance-Duffadar Mumtaz Ali Khan.	Fever every day with shivering.	Malarial parasites.
4	Lance-Duffadar Udesing's child.	Suffering from fever for for some time.	Malarial parasites.

In 1908 Major Liston, I. M. S., and Captain Mackie, I. M. S., investigated the spleen index and parasite index among young children in Frere Road. The spleen index was ascertained to be 80 per cent. and the parasite index over 50 per cent.

64. Beyond these few facts little or nothing can be learned regarding the amount of malaria existing in Bombay except what can be gathered from hospital returns. Unfortunately, with the exception of the Police Hospital, the systematic examination of the blood of fever cases does not appear to have received much attention in hospitals and dispensaries in the City and the value of returns obtained from them is greatly lessened by this fact.

65. The most valuable means of measuring the amount of malaria in a locality is the estimation of—

(1) The spleen index.

(2) The parasite index.

Section 1. THE SPLEEN INDEX.—It has been known for very many years that malaria often produced enlargement of the spleen in those who suffered from the disease. More than fifty years ago certain medical officers in the Punjab carried out a spleen census in order to estimate the prevalence of malaria among the population of some of the irrigated tracts; and the taking of a spleen census has

now become a routine method of measuring the malaria of a community, as it is generally recognized that in the absence of a disease such as Kala-azar, which also causes splenic enlargement, a very good idea of the prevalence of malaria may be arrived at by estimating the proportion of a population possessing palpably enlarged spleens. Usually such a census is taken among young children only, because observations made upon persons of different ages resident in malarious countries show that after a certain age splenic enlargement becomes much less common, owing probably to the occurrence of a condition of toleration or partial immunity, produced by long exposure to infection.

The exact significance of splenic enlargement is not clear. Many cases of mild malarial infection fail to show an appreciable enlargement of the spleen and in a considerable proportion of cases with marked enlargement, undoubtedly due to antecedent malaria, examination of the blood fails to reveal the presence of parasites. But although there are grounds for believing that enlargement of the spleen indicates the previous occurrence of malarial disease more certainly than the existence of present infection, this fact in no way invalidates the use of the splenic index as a measure of the malaria present among a community; and the taking of a spleen census is the simplest and probably under ordinary conditions the most accurate method that can be adopted for estimating the amount of malaria existing among a large population.

66. *The Spleen Census in Bombay.*—At the commencement of the present enquiry Captain A. G. McKendrick, I. M. S., conducted a spleen census by a system of "*random sampling*" with the following results:—

Result of the First Spleen Census.

Ward.	Number of children examined.	Number of children with enlarged spleen.	Percentage of children with enlarged spleen.
Ward A.	762	271	35·0
„ B.	1,304	154	11·0
„ C.	1,002	38	3·0
„ D.	846	33	3·9
„ E.	1,650	91	5·5
„ F.	1,459	21	1·4
„ G.	1,302	18	1·3
Total ...	8,325	626	7·5

By means of this spleen census Captain McKendrick was able to map out the areas most severely affected by malaria and the results obtained subsequently coincide very closely with those observed by him.

67. But it has been found that a spleen census by the method of "*random sampling*," though sufficiently accurate when dealing with large areas, does not afford enough detailed information. A second house-to-house spleen census was therefore undertaken in different sections of the City, and a very large number of children were examined with the following results:—

Result of Final Spleen Census.

Ward.	Number of children between the ages of 1 to 10 in 1906.	Number of children examined.	Number with enlarged spleen.	Percentage with enlarged spleen.
Ward A.	7,170	5,944	1,783	29·9
„ B.	21,108	5,980	781	13·0
„ C.	23,964	12,025	711	5·9
„ D.	14,780	7,532	208	2·7
„ E.	30,942	11,646	213	1·8
„ F.	13,146	5,513	66	1·1
„ G.	14,331	3,896	41	1·0
Total ...	125,441	52,536	3,803	7·2

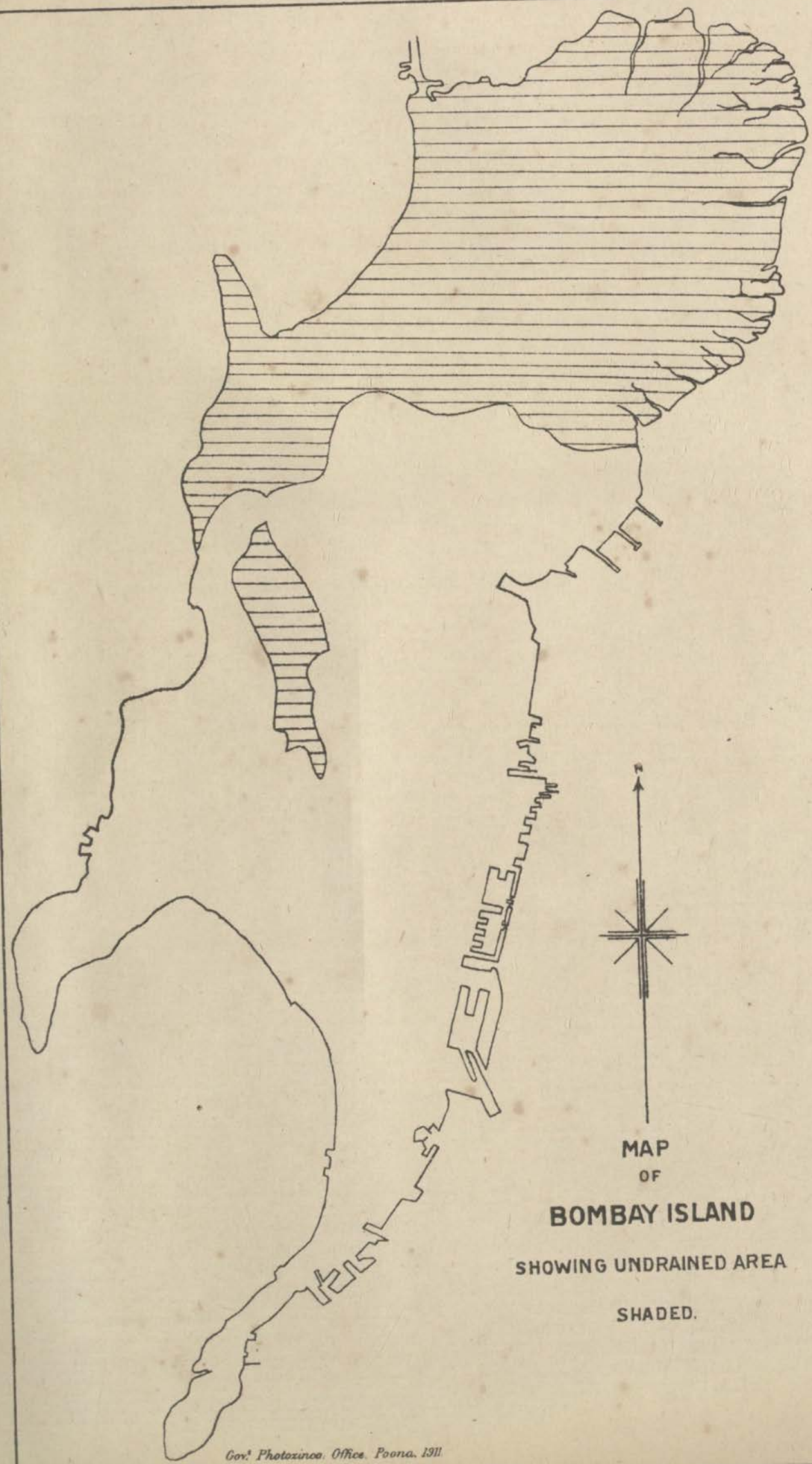
Altogether a total of over 70,000 children have been examined since the enquiry commenced. Certain sections have been examined more than once and 3,482 children from whom blood specimens were taken were also examined for spleen enlargement. Of these children, 562 or 16·1 per cent. had enlarged spleen. A total of 1,265 belonged to A. and B. Wards and of these 426 showed enlarged spleens or 33·6 per cent. Of the remaining 2,217 from other parts of the island, 136 showed enlarged spleens, or 6·1 per cent.

68. In Mauritius, Ross found 10,595 children with enlarged spleen out of a total of 31,022 examined or 34·1 per cent.; and in Ceylon a spleen census carried out in 1908 by the orders of the Principal Medical Officer, showed 31,421 children among a total of 92,258 with splenic enlargement—a percentage of 34·05 per cent. Compared with these figures the percentage of enlarged spleens observed among the children in Bombay is low, and it may be said as a result of the spleen census that, the island of Bombay as a whole is not very malarious. But as may be seen from a comparison of the figures for the various wards in the City there are great differences in the incidence of malaria in different localities. In the north of the Island, which is undrained, and subject to flooding during the monsoon, and which has generally been considered exceedingly malarious, the spleen index approaches zero; in the centre of the Island the spleen index though a little higher is still very low; and it is only in the southern portion of the City that it shows any considerable rise.

69. The result of the spleen census in different sections of each ward is shown on the following table:—

Result of Spleen Census by Sections.

Sections.		Time of year.	Number of children examined.	Number with enlarged spleen.	Percentage with enlarged spleen.
A. Ward	Upper Colaba	April, July	212	15	7·07
	Middle and Lower Colaba	April, August	762	90	11·8
	South Fort	April, December	227	47	20·7
	North Fort	April and May	3,987	1,311	33·0
	Esplanade	April, January	756	320	42·3
B. Ward	Mandvi	April and May	1,223	456	37 8
	Chakla	April	684	74	11·34
	Umarkhadi	October	1,939	171	9·0
	Dongri	June and July	2,134	80	3·7
C. Ward	Market	August	1,727	247	14·3
	Dhobi Talao	August	3,150	359	18·8
	Fanaswadi	December	1,646	57	3·4
	Bhuleshwar	November	1,941	105	5·4
	Khara Talao	November	1,841	98	5·4
	Kumbarwada	February	1,720	46	2·6
D. Ward	Girgaum	January	1,520	48	3·06
	Chowpati	March and April	1,030	26	2·5
	Khetwadi	February and March	2,335	50	2·1
	Walkeshwar	January and April	1,222	39	4·7
	Mahaluxmi	January and April	1,825	45	2·4
E. Ward	Byculla	August	2,177	41	1·8
	Tardeo	April and May	1,609	21	1·3
	Kamatipura	July	1,631	18	1·1
	1st Nagpada	August	1,629	15	0·9
	2nd Nagpada				
	Mazagaon	January and May	3,110	86	2·7
	Tarwadi	January and June	1,490	32	2·1
F. Ward	Parel	August	3,277	47	1·4
	Sewri	September	1,242	9	0·7
	Sion	November	994	10	1·05
G. Ward	Mahim	October and Nov.	1,416	11	0·7
	Worli	Sept. and October	2,480	30	1·2



MAP
OF
BOMBAY ISLAND
SHOWING UNDRAINED AREA
SHADED.

Gov.t Photozinco. Office. Poona. 1911.

Comparision of the tables showing the spleen index of wards and sections, shows how the pooling of figures may obscure the real condition of things. Thus in the first table Ward C. appears far less affected than A. and B., but reference to the second table shows that portions of C. Ward are really more affected than parts of A. and B. Wards. This matter is exceedingly important as it shows how closely the incidence of malaria is related to local conditions. If we follow a line drawn across the island from east to west, cutting through in succession Mandvi, Chakla, Market and Dhobi Talao Sections, we find—

(1) Mandvi severely affected with malaria with a spleen index of 37·8 per cent.,

(2) Chakla less so with a spleen index of 11·3 per cent.,

(3) Market more severely affected than Chakla with a spleen index of 14·3 per cent., and

(4) Dhobi Talao at the extreme west and separate from Mandvi by two-thirds of a mile of streets and houses with a spleen index of 18·8 per cent. higher than either Market or Chakla Sections.

These observations point to the existence of a source of malarial infection in the west of the island distinct from that responsible for the disease in Mandvi, and investigation has shown this idea to be well found.

70. The areas most severely affected by malaria are Esplanade, North Fort and Mandvi Sections. These sections immediately adjoin the enclosure of the New Dock Works and at first sight it might appear that proximity to the work in progress there was the sole cause of their being severely affected by malaria. But more detailed enquiry shows that although this explanation holds good in regard to Mandvi and Esplanade Sections it is not equally so of North Fort. In the first detailed spleen census of the Fort in 1909, 48·7 per cent. of children living between Frere Road and the New Dock showed enlarged spleen, 27·8 per cent. of those living between Mint Road and Frere Road, 35·5 per cent. of those living east of Parsi Bazar Street and 42·8 per cent. of those living west of Parsi Bazar Street. And the second spleen census in 1910 shows that if we follow a line drawn diagonally through North Fort Section, from Fort Street on the extreme east to the corner of Church Gate Street and Hornby Road on the west, we find, first an area near the Dock Works with a spleen index of 35·4 per cent., then west of this an area with a lower spleen index of 21 per cent., then further to the west another area with a spleen index of 35·6 per cent. and in extreme west of the section farthest removed from the Dock Works an area with a spleen index of 42·5 per cent. We have then in the North Fort a portion that has been adversely affected by proximity to the New Dock Works and over and above this another and much larger area lying to the west which is seriously affected by malaria owing to some other cause. This latter cause is of a similar nature to that giving rise to a serious amount of malaria in Dhobi Talao Section, namely, the existence of hundreds of private house-wells breeding malaria-carrying mosquitoes.

71. One of the most interesting and important facts brought out by the spleen census is the comparative freedom of the whole of the north of the island from any serious amount of malaria. It has been supposed for hundreds of years that the ill-drained, low-lying areas in the Centre and North of Bombay, were more malarious than the older portions of the City on the higher land to the south. But it is a significant fact that among 6,132 children living in the undrained portion of the island only 60 or 0·9 per cent. showed splenic enlargement, whereas among 46,404 living in the drained portion 3,743 or nearly 8 per cent. have enlarged spleen. It must be pointed out however that the apparent relation of malaria to drainage is an accident, due to the fact that breeding places favoured by the chief malaria-carrying anopheles of Bombay happen to be present in the drained area and absent in the undrained one. This mosquito *Neocellia stephensi* does not breed in the foul water of house and street drains and sewers, so that the existence of drains is not responsible for the presence of malaria.

72. It was commonly suggested in the past that the existence of the low-lying area in the centre of the island known as the "Flats" was the cause of a considerable amount of malaria. This area, which is mostly below high-tide level, contains the Mahaluxmi storm-water reservoir, and in the monsoon many large pools of water collect there. It has often been supposed that these collections of water were responsible for a great deal of malaria in the areas around them. But this idea is shown to be quite as erroneous as that regarding the supposed malariousness of the north of the island, for only 137 children out of a total of 8,097 examined in Byculla, Tardeo, Mahaluxmi and Worli Sections — an area which includes the whole of the "Flats"—were found to have enlarged spleen, giving a very low index of 1·6 per cent. These observations show that malaria cannot be included among the serious causes of ill-health in the undrained and low-lying parts of Bombay Island.

73. Another fallacy regarding Bombay malaria, which has been commonly accepted in the past, is the suggestion that much of the malaria in the City was due to the importation of the disease and that this source of infection was so common as to render it exceedingly doubtful if measures taken to prevent the breeding of malaria-carrying anopheles would be of much effect. But from the figures of the spleen census we are justified in assuming that imported malaria is in reality only a small matter, for if we allow that of the people who come to Bombay from other places, one-half resides in the centre and north of the island, in other words in Wards D., E., F. and G., which at the last census showed a population of 529,980 people, they do not appear to increase the amount of malaria there to any great extent. Among 28,587 children resident in these wards only 528 or 1·8 per cent. showed enlarged spleen, so that even if we consider the whole of this as due to importation, there remains an excess of malaria in the south of the island, as shown by the spleen rate of 13·6 per cent. among 23,949 children in A., B. and C. Wards, which can only be explained by the occurrence of local infections.

74. Among a total of over 50,000 children examined on the island whose race was ascertained, the figures for the spleen census work out as follows :—

	Number examined.	Number with spleen.	Percentage with spleen.
Hindus	40,509	2,170	5·3
Mussulmans	4,462	448	10·0
Parsis	4,387	1,020	23·2
Jews	481	27	5·6
Christians*	1,409	125	8·8

* The latter include Europeans, Eurasians, East Indians and Goanese, etc.

From this it will be seen that Parsis as a community are the greatest sufferers from malaria. The explanation is to be sought in the fact that a large proportion of the total Parsi population is resident in north Fort and Dhobi Talao Sections in which, as we have seen, there is a serious amount of malaria.

As will be seen later, the cause of the great amount of malaria in these two sections is the existence of large numbers of open wells infested with *larvæ* of *Neocellia stephensi*. There are close on 600 wells in the 133 acres of north Fort and about 450 in the 99 acres of Dhobi Talao. A very large proportion of the wells in both these sections are inside dwelling houses; and many Parsis are found living in houses possessed of open wells in the basement.

75. The spleen census in Fort north and Dhobi Talao shows the following figures for different races :—

North Fort.

	Number examined.	Number with spleen.	Percentage with spleen.
Hindus	1,486	437	29·5
Mussulmans	195	66	33·8
Parsis	2,168	769	35·4
Christians	123	45	24·6

Dhobi Talao.

	Number examined.	Number with spleen.	Percentage with spleen.
Hindus	1,961	324	16·5
Mussulmans	34	7	20·5
Parsis	792	196	24·7
Christians	254	34	13·3

These figures show that in both North Fort and Dhobi Talao Sections Parsis suffer in greater proportion than in any other race ; and this is in spite of the fact that as a community they are comparatively well-off, are better educated than either Hindus or Mussulmans and, as a rule, receive treatment from qualified medical practitioners.

76. The distribution of enlarged spleen by wards and races is as follows :—

	Number examined.	Number with spleen.	Percentage with spleen.
A. Ward.			
Hindus	3,158	407	16·5
Mussulmans	289	89	30·7
Parsis	2,187	783	27·2
Christians	225	61	27·2
Jews	10	1	10·0
B. Ward.			
Hindus	4,034	525	13·01
Mussulmans	1,596	235	14·7
Parsis	3	.....	.....
Christians	113	8	7·08
Jews	234	23	9·8
C. Ward.			
Hindus	9,334	798	8·5
Mussulmans	1,712	83	4·8
Parsis	887	204	22·9
Christians	263	34	12·8

	Number examined.	Number with spleen.	Percentage with spleen.
D. Ward.			
Hindus	6,097	165	2·7
Mussulmans	224	10	4·4
Parsis	1,088	29	2·6
Christians	120	3	2·5
E. Ward.			
Hindus	9,310	179	1·9
Mussulmans	1,520	24	1·5
Parsis	189	4	2·1
Christians	390	15	3·8
Jews	237	3	1·2
F. Ward.			
Hindus	5,202	60	1·1
Mussulmans	253	5	2·06
Parsis	1	.....	.....
Christians	67	1	1·5
G. Ward.			
Hindus	3,374	36	1·06
Mussulmans	259	2	0·8
Parsis	32	.....	.....
Christians	231	3	1·2

77. Ross in his report upon malaria in Mauritius states that, in conducting the spleen census among young children there, the size of palpable spleens were roughly classified as small, medium and large ; and more recently Christophers has pointed out that it is often very desirable to express the spleen rate in a more extended form than is usually done.

He suggests the classing of spleens into 5 classes as follows :—

(1) Spleen not palpable.

(2) Spleen palpable up to one finger's breadth below costal margin.

(3) Spleen two to three fingers' breadth below costal margin.

(4) Spleen a hand's breadth below costal margin.

(5) Spleen very large, reaching to umbilicus or beyond.

Unfortunately the measurement of the spleen is difficult, and different observers are not likely to conform to the same standard very accurately, so that although a series of different observations by one man may be comparable to one another, the comparison of figures obtained by different observers is not so likely to be of value.

In the second spleen census in the North Fort the size of the spleens observed were roughly noted. The number observed and the percentage of each size are as follows :—

Table of Spleens in North Fort classified according to size.

Observations.	No. 1.		No. 2.		No. 3.		No. 4.		No. 5.	
	Not palpable.	Per-centage.	Enlarged up to 2 fingers' breadth.	Per-centage.	Enlarged up to 3 fingers' breadth.	Per-centage	Enlarged up to 4 fingers' breadth.	Per-centage.	Very large, above a hand's breadth below costal margin.	Per-centage.
Total, 3,987	2,676	67·1	552	13·8	532	13·6	175	4·3	40	1·0

The results found among Parsis and other classes in the north Fort is noted below :—

	Percentage, Class No. 1.	Percentage, Class No. 2.	Percentage, Class No. 3.	Percentage, Class No. 4.	Percentage, Class No. 5.
Parsis	61·3	14·1	14·8	5·0	1·2
Other Classes	70·2	13·5	12·2	3·2	0·7

Section 2.

78. BLOOD EXAMINATION.—Although the spleen census gives most valuable information regarding antecedent malaria and may be used as a measure of malarial endemicity, the microscopic examination of the blood gives information regarding the actual presence of infection, and the species of parasite, not to be gained in any other way. Years ago Stephens and Christophers suggested, as a measure of malarial endemicity, the use of an infection index arrived at by the microscopical examination of the blood of young children. This suggestion was based upon a consideration of the following facts. In a very malarious locality nearly all new comers usually contract malaria after a short stay of days or weeks; in a less malarious locality a smaller proportion become infected in a given period; and in a place where malaria is only mild, new comers may escape infection for months or even years. Therefore the examination of new comers for the presence of malarial infection enables the observer to arrive at a figure of value for comparative purposes; and as a rule young children are selected for the purposes of this examination because they form a class of new comers more or less fixed in character and available everywhere. But in Bombay, where a large proportion of the population is formed of new arrivals and temporary residents, there are many thousands of adults who are probably quite as susceptible to malarial infection as young children; and it has been found that the adult population of malarious localities in the City is infected with malaria in much the same proportion as the child population. During the present enquiry a large number of blood films have been collected from both children and adults in different parts of the City. As it is quite impossible to examine the blood of more than a small proportion of the population in a City as large as Bombay, it was necessary to adopt a system of "*random sampling*," when obtaining specimens for the estimation of the parasite index. The method employed in the collection of blood films during the investigation was as follows:—A locality, chosen indiscriminately, was visited usually in the early morning. Conversation was exchanged with some resident or passer-by until a crowd collected. After a little persuasion, some one would consent to allow his finger to be pricked and a blood film prepared, and it would soon become fashionable to follow suit. Children coming forward or brought by their parents were rewarded with a pice. In this way it was usually possible in the course of an hour to collect 50 or 60 blood films, specimens being taken from every one in the crowd who appeared willing. Blood films were collected in this manner from over 100 localities in different parts of the City.

79. *Parasite Index.*—The parasite index of the different wards in the City obtained by the examination of the blood of people from about 100 different localities is as follows:—

Tables of blood examination showing the amount of street infection in each ward.

Ward.	Number examined.	Number infected.	Percentage infected.
Ward A.	2,681	943	34·8
„ B.	473	65	13·7
„ C.	707	196	27·7
„ D.	354	19	5·3
„ E.	878	33	3·7
„ F. and G. ...	302	11	3·6
Total ...	5,395	1,267	23·4

It will be seen from this table that the greatest amount of infection is present in the Wards which showed a comparatively high spleen index among young children. But there is not quite a direct correspondence, for the parasite index of C. Ward is higher than that of B. Ward, whereas B. Ward showed a higher spleen index than C. Ward. This is no doubt chiefly due to the fact that blood films were obtained at different times of the year, but it is possible that other causes are partly responsible for the difference. Malaria in B. Ward has been mainly due to diffusion of anopheles from the New Dock area and this would only occur during the rains and for a short time afterwards. In C. Ward malaria is spread by anopheles which can breed uninterruptedly throughout the year in open wells. In Wards D., E., F. and G. the parasite index is very low.

80. As has been stated previously, in Bombay there is generally little variation in the number of infections met with in adults and children. This is shown by a comparison of the following table:—

Malaria parasite index.

(Street infection among adults.)

Ward.	Number examined.	Number infected.	Percentage infected.
Ward A.	948	324	34·1
„ B.	297	41	13·8
„ C.	271	59	21·7
„ D.	121	10	8·2
„ E.	279	10	3·5
„ F. and G. ...	68	4	5·8
Total ...	1,984	448	22·5

The parasite index among young children is as follows:—

Malaria parasite index.

(Street infection among children.)

Ward.	Number examined.	Number infected.	Percentage infected.
Ward A.	1,733	609	34·8
„ B.	182	24	13·1
„ C.	388	134	34 5
„ D.	233	9	3·8
„ E.	599	23	3 8
„ F. and G. ...	234	7	2·9
Total ...	3,369	806	23·6

81. The figures of the parasite indices of smaller areas than wards are as follows:—

Sectional Table of blood examinations for Parasite Index.

Ward and Section.		Time of year.	Number examined.	Number infected.	Percentage infected.
A. Ward...	Upper Colaba ...	June and July ...	28	1	3·6
	Middle and Lower Colaba.	May, August and Oct. ...	223	44	19·7
	South Fort ...	July ...	71	16	22·5
	North Fort ...	May, June, July and Dec.	459	160	34·9
	Esplanade ...	All times of the year ...	1,900	712	37·5
B. Ward...	Mandvi ...	May and July ...	155	29	18·7
	Chakla ...	May ...	85	9	10·6
	Umarkhadi ...	December ...	161	21	13·0
	Dongri ...	June ...	72	6	8·3

Ward and Section.	Time of year.	Number examined.	Number infected.	Percentage infected.
C. Ward ... Market	June and September	102	29	28·4
C. Ward ... Dhobi Talao	April, October and Dec.	306	125	40·8
C. Ward ... Fanaswadi	October	58	15	25·9
C. Ward ... Bhuleshwar	July and December	97	12	12·4
C. Ward ... Khara Talao	November	96	12	12·5
C. Ward ... Kumbarwada	October and November	48	4	8·3
D. Ward ... Khetwadi	November	31	1	3·2
D. Ward ... Girgaum	June and November	103	8	7·8
D. Ward ... Chowpati	July and November	58	8	12·9
D. Ward ... Walkeshwar	September	58	1	1·7
D. Ward ... Mahalaximi	December	104	1	1·0
E. Ward ... Byculla	August	361	8	2 2
E. Ward ... Tardeo	August	187	5	2·7
E. Ward ... Kamatipura	May	60	1	1·7
E. Ward ... 1st Nagpada	September	54	2	3·7
E. Ward ... 2nd do.	September	151	16	10·6
E. Ward ... Mazagaon	May	65	1	1·5
E. Ward ... Tarwadi	May			
F. Ward ... Parel	June and July	65	4	6·2
F. Ward ... Sivri	June	47	...	0·0
F. Ward ... Sion	June	113	5	4·4
G. Ward ... Mahim	July	54	2	3·7
G. Ward ... Worli	July	23	...	0·0
Total		5,395	1,267	23·4

The result of the microscopical examination of these films confirms the conclusion regarding the general distribution and incidence of malarial infection in Bombay, arrived at by the spleen census. Thus wherever the spleen census indicates the presence of a large amount of malaria, as in north Fort, Esplanade, Mandvi, Market and Dhobi Talao, the parasite index both among adults and children is relatively high, and wherever the spleen index is low, the parasite index is found to be low also. But although there is a general correspondence between the two sets of observations it is not quite an exact one. Thus both spleen index and parasite index nearly approach one another when they are high, but the spleen index falls more rapidly than the parasite index; and a parasite index of 10 per cent. or 12 per cent. may be found in an area where the spleen index is as low as 5 per cent. It is of course possible that this may in part be due to an unconscious selection of cases for blood examination. It has been noticed that the person who has been ill or is feeling unwell, especially in the case of adults, is often more willing to offer himself for blood examination than the person who is feeling quite fit. But in the case of young children, who are tempted to submit to having their fingers pricked, by the offer of a reward, this selection factor is not of great importance.

82. *Numerical estimation of parasites.*—At the outset it was decided to attempt a rough numerical estimate of the parasites present in infected specimens and as a routine plan 150 microscopic fields were examined in each film, a 1-12th oil immersion objective and a No. 1 eye piece being used. A field of this size contains on the average about 200 red blood corpuscles and thus about 30,000 red blood corpuscles were examined from each case. To test the value of this method, in one batch of 61 slides, the examination of each film not found infected in 150 fields was extended to a maximum of 600 fields or approximately 100,000 to 120,000 red blood corpuscles.

The following table gives the results obtained in this test examination :—

No.	Microscopic fields examined.	Result.
1	600	Nil.
2	600	Nil.
3	600	Nil.
4	600	Nil.
5	600	One quartan gamete in field 187.
6	600	Nil.
7	600	Nil.
8	300	One crescent in field 117. One benign tertian gamete in field 231.
9	300	One benign tertian ring in each of fields Nos. 232 and 289.
10	600	Nil.
11	150	One benign tertian ring and one gamete.
12	600	Nil.
13	150	One malignant tertian ring.
14	600	Nil.
15	600	Nil.
16	600	Nil.
17	150	Four corpuscles infected with malignant tertian rings, one containing four separate rings.
18	600	Nil.
19	600	Nil.
20	200	Nil.
21	600	Nil.
22	150	One benign tertian half grown ring.
23	600	Nil.
24	600	Nil.
25	600	Nil.
26	600	Nil.
27	100	25 benign tertian, large pigmented rings.
28	600	Nil.
29	600	Nil.
30	150	One benign tertian pigmented ring and one gamete.
31	600	Nil.
32	600	Nil.
33	600	Nil.
34	300	2 malignant tertian rings, one each in fields 261 and 286.
35	300	One benign tertian gamete in field 219.
36	100	12 benign tertian rings.
37	150	One benign tertian gamete.
38	600	Nil.
39	600	Nil.
40	600	Nil.
41	600	Nil.
42	300	One crescent in field 244.
43	100	20 malignant tertian rings.
44	300	One benign tertian gamete in field 271.
45	600	Nil.
46	150	One malignant tertain ring.
47	150	One benign tertian ring.
48	600	Nil.
49	100	20 quartan rings, large.
50	600	Nil.
51	600	Nil.
52	300	One crescent in field 283.
53	600	Nil.
54	600	Nil.
55	600	Nil.
56	600	Nil.
57	600	Nil.
58	150	One malignant tertian ring.
59	100	124 benign tertian parsites, rings sprolating, bodies and gametes.
60	600	Nil.
61	600	Nil.

All the films referred to above were taken from children resident in the same locality. Among them some had only recently come to Bombay, others had just returned from a visit to their country but the majority had been resident over a year.

Those mentioned below had not been long in residence.

No.	19	... 3 days	from country.
,,	24	... 2 ,,	,, ,,
,,	26	... 1 month	,, ,,
,,	29	... 8 days	,, ,,
,,	39	... 2 months	,, ,,
,,	50	... 1 month	,, ,,
,,	51	... 2 months	,, ,,
,,	52	... 3 days	,, ,,

It will be seen from the table that 22 or 36 per cent. out of the total of 61 children showed malarial parasites in their blood. But if only 150 microscopic fields had been examined, seven infections, Nos. 5, 9, 34, 42, 44 and 52 would have been overlooked and the infection index would have stood at 15 out of 61 or 24·5 per cent., a difference of 11·5 per cent. Only one among the eight children arrived from their country showed a scanty infection. If these eight are deducted from the total examined, the resulting parasite indices at 150 and 600 fields examined would have been 28·3 per cent. and 39·6 per cent. respectively.

From these observations it may be assumed that an examination extending over 150 microscopic fields only reveals about two-thirds of the infections shown by an examination prolonged for four times this period and it follows that a parasite index obtained by the former method must be raised at least 50 per cent. in order to show a near approximation to the actual rate of infection.

None of the eight children recently arrived from their country showed palpable enlargement of the spleen, but of the remaining 53, 15 showed splenic enlargement; and of the latter, 9 had parasites in their blood.

83. *Relative Intensity of Infections.*—The varying intensity of different infections is well shown in the following table which gives an analysis of 1,052 separate cases in which malarial parasites were found on examination of the blood :—

Number of parasites in 150 microscopic fields.	Number of cases.	Percentage of total examined.
1	234	22·24
2	160	15· 2
3	101	9· 6
4	67	6· 3
5	46	4· 3
6	51	4· 8
7	14	1· 3
8	17	1· 6
9	31	2· 9
10	14	1· 3
10—15	66	6· 2
15—20	38	3· 6
20—30	74	7· 0
30—50	46	4· 3
50—100	31	2· 9
over 100	62	5· 8

84. A comparison of the infections met with in the various wards, from the point of view of number of parasites per infected person, reveals the fact that the average number of parasites present varies in different localities, but shows a more or less direct relation with the parasite index.

Average number of parasites per infected person.

Ward A.	...	...	21·9	in 150 miscroscopic	fields.
„ B.	...	...	16·3	„ „	„
„ C.	...	...	18·9	„ „	„
„ D.	...	...	6·4	„ „	„
„ E.	...	...	9·4	„ „	„
„ F. and G.		...	2·1	„ „	„

The above table shows that not only is there a very much larger proportion of people in A., B. and C. Wards infected with malaria than in D., E., F. and G. Wards, but the character of the infections differs enormously also. On the average the infections in the first area (A., B. and C. Wards) are nearly four and a half times as heavy as those in the second (D., E, F. and G. Wards). It follows therefore that the total number of malarial parasites present in a given number of infected persons in A., B. and C. Wards is far in excess of that present in D., E., F. and G. Wards and the comparison of the mean parasite indices of the two areas 31·1 per cent. and 4·1 per cent. does not afford a direct measure of the relative amount of malaria in each area. If we divide the parasite index of A., B. and C. Wards taken together, with the parasite index of D., E., F. and G. Wards taken together we obtain the following result :—

$$\frac{31\cdot1}{4\cdot1}=7\cdot5$$

Thus 7·5 to 1 may be said to represent the relative frequency with which malarial infections are met with in the two areas under discussion. But we are not justified in saying that the first area (A., B. and C. Wards) is only 7·5 times more malarious than the rest of the island. The infections met with in those wards are on the average 4·3 times as heavy as those met with in D., E., F. and G. Wards and $7\cdot5\times4\cdot3=32\cdot25$ represents a nearer approximation to the truth.

Broadly speaking we may say therefore that the south of Bombay Island is about thirty times as malarious as the north.

85. The following table gives further details of the percentage of heavy and scanty malarial infections met with in different parts of the City :—

Number of parasites per infection (150 microscopic fields).	Percentage of malarial infections in each ward, showing given number of parasites.					
	A.	B.	C.	D.	E.	F. and G.
1—4 ...	40·3	57·5	61·8	80·0	69·4	92·8
5—10 ...	12·5	16·4	13·0	6·6	16·6	7·1
10—50 ...	25·9	17·8	17·5	13·3	13 8	0·0
50—100 ...	6·7	1·3	1·5	0·0	0·0	0·0
100 and over	14·1	4·1	6·1	0·0	0·0	0·0

When we remember that, an examination of 150 microscopic fields or 30,000 corpuscles reveals only two-thirds of the infections shown by a more extended examination of at least 100,000 corpuscles, it will be seen that, the vast majority of malarial infections are but very scanty ones. Ross has estimated that at least one parasite among 10,000 corpuscles is probably the minimum required to produce an attack of fever; but there are strong grounds for supposing that in ordinary cases many more than this may be supported for a considerable time without causing noticeable symptoms. The majority of the cases of infection recorded in the above table showed no fever, a very large proportion had no palpable enlargement of the spleen, and it was the rule for them to deny the suggestion of being ill.

86. *Species of Parasite present in Bombay.*—Three species of malaria parasite are now generally recognized and each of them is present in Bombay. The proportion of each species met with during the enquiry was as follows :—

Among 1,368 cases of infection examined—

621 or 46·1 per cent. were malignant tertian.
589 or 43·0 „ „ „ benign tertian.
148 or 10·8 „ „ „ quartan.

Powell during the examination of a large number of malarial bloods in Bombay in 1901-1903 found—

1,382 benign tertian infections or 52·9 per cent.
1,186 malignant „ „ or 45·4 „
41 quartan infections or 1·5 „

A comparison of these figures indicates that there has been an increase of quartan malaria in recent years. Among 357 cases in which sexual forms of the malaria parasite were observed during the recent enquiry—

142 or 39·7 per cent. were benign tertian.
121 or 33·6 „ „ „ crescent malignant tertian.
94 or 26·3 were quartan.

These figures indicate that a still further increase of quartan malaria may occur in the future.

87. *Seasonal Infection.*—A series of observations conducted in one of the most malarious localities throws some new light on the course of the seasonal incidence of malaria. Blood specimens were collected at intervals from two large chawls A and B, both containing many hundreds of people.

The observations upon chawl A are as follows :—

Infection indices in chawl A showing seasonal incidence and intensity.

Serial number.	Date of observation.	Blood specimens examined.	Number infected.	Percentage infected.	Average number of parasites per 150 fields.
1	10th June 1909	171	92	53 8	35·0
2	29th September 1909	100*	34	34·0	30·4
3	14th December 1909	165*	48	29·1	8·2
4	13th April 1910	55	11	20·0	2·8
5	19th „ „	50	12	24·0	2·8
6	11th June „	61	15	24·5	21·0
7	11th July „	70	22	31·4	13 1
8	22nd August „	52	20	38·5	42·9
9	4th October „	54	28	51·9	13·8
10	6th December „	60	16	26·7	8·7

This table refers to blood from both children and adults.

The children taken by themselves gave the following series of indices :—

Serial number.	Month.	Number examined.	Number infected.	Percentage infected.
1	June	107	59	55·1
2	September	69*	20	29·0
3	December	104*	34	32·7
4	April	51	10	19·6
5	„	29	5	17·2
6	June	55	14	25·4
7	July	68	21	30·9
8	August	44	19	43·2
9	October	42	22	52·4
10	December	50	12	24·0

Chawl B although situated very near chawl A did not show as high an infection index and the infections met with were much more scanty than those in chawl A.

* Many residents receiving quinine.

Infection indices in chawl B showing seasonal incidence and intensity.

Serial number.	Date of observation.	Number examined.	Number infected.	Percentage infected.	Average number of parasites per 150 fields.
1	23rd June 1909	150	60	40·0	15·9
2	2nd August „	95*	30	31·6	17·4
3	9th November „	103*	45	43·6	4·4
4	7th May 1910	75	16	21·3	4·0
5	11th June „	51	8	15·7	7·1
6	11th July „ †	42	8	19·0	2·7
7	30th August „ †	50	12	24·0	5·8
8	5th October „ †	64	20	31·2	6·4

* Many residents receiving quinine. † Observations made by a different observer.

88. Chawl A was composed of lines of single storied huts built of corrugated iron and provided with roomy open verandahs in which many of the people used to sleep. An inspector visited this chawl daily and it was kept in a very clean and orderly condition. Chawl B was composed of three two-storied blocks of back to back tenements, dark, filthy and overcrowded. These tenements were provided with a very narrow landing or verandah which the tenants mostly shut in with matting. The windows also were all stopped up with paper and rags. It appears probable that anopheles mosquitoes obtained access to chawl A with much greater ease than to chawl B on account of the open site of the former chawl and the fact that windows and verandahs were not allowed to be closed in as in chawl B. A considerable portion of the inmates of both these chawls were in receipt of quinine treatment from the middle of August to December 1909. During 1910 they got no treatment.

89. The ten different occasions upon which bloods were examined from A chawl showed a varying percentage of light and heavy infection.

Serial number.	Month.	Percentage of infections showing under 10 parasites in 150 microscopic fields.	Percentage of infections showing over 100 parasites in 150 microscopic fields.
	A Chawl.		
1	June 1909	54·6	10·3
2	September „	67·7	11·7
3	December „	83·3	...
4	April 1910	100·0	...
5	„ „	83·3	...
6	June „	62·5	6·2
7	July „	81·8	4·5
8	August „	45·0	10·0
9	October „	64·2	3·5
10	December „	68·9	...
	B Chawl.		
1	January 1909	70·0	5·0
2	August „	63·5	6·6
3	November „	97·7	...
4	May 1910	93·7	...
5	June „	75·0	...
6	July „	*100·0	...
7	August „	*75·0	...
8	October „	*90·0	...

* Observations made by a different observer.

These observations appear to show that there is a seasonal rise and fall in the total number of infections in a given area and a corresponding seasonal increase or decrease in the intensity of the infections met with; and they also support the view that there is a direct relation between the presence of high or low endemic indices and the occurrence of malarial infections of high or low intensity.

90. *Relation of parasites to splenic enlargement.*—The question has been occasionally raised as to the relative enlargement of the spleen produced by the different species of the malaria parasite. During the enquiry this point was examined into in the case of 176 persons possessed of very large spleens extending to the umbilicus or below it.

Of these—

70 showed no parasites.
41 „ malignant tertian parasites.
58 „ benign tertian parasites.
7 „ quartan parasites.

Among the 41 cases infected with malignant tertian malaria only 7 showed the presence of crescents. Among a total of 121 crescent infections 75 showed enlargement of the spleen and 38 no palpable enlargement. Among 1,654 persons with enlarged spleen whose blood was examined for malarial parasites in 862 or 52·1 per cent. no parasites were detected; and among a large number of persons without palpable spleen whose blood was examined microscopically 545 showed the presence of malaria organisms.

Section 3.

91. MALARIA AS A CAUSE OF DEATH IN BOMBAY.—Unfortunately little or nothing can be learned until quite recent times of the effect produced by malaria on the health of the general population of Bombay, and even now it is not possible to make more than a very rough estimate of the total morbidity and mortality occurring in the City from this cause. At the beginning of the 19th century the average annual mortality in the City ranged from 4,000 to 8,000 rising to 26,000 in 1804 in consequence of famine in the Konkan. The most common causes of death were stated to be fever and liver complaint, but it is doubtful if much of this was due to malaria, as in 1825 Seely stated that "the salubriety of Bombay caused it to be "resorted to by invalids from other Presidencies and the interior."

But on occasion fever has claimed a large toll of human life, as for example between 1863 and 1866, when scarcity in the rural districts and commercial activity in the City led to a great immigration of labourers. It is quite possible that malaria may have played some part in increasing mortality at this time, for a number of reclamation works were commenced during this period, and there are reasons for supposing that the Back Bay Reclamation especially led to an increase of malaria in the parts of the City adjoining it.

In 1877 when the City was filled with famine-stricken people from the Deccan, Gujarát and Rájputána, fever caused a heavy mortality; but this fever was chiefly relapsing fever, a fact shewn by Vandyke Carter, who reported on it at the time. From 1878 to 1901 the annual deaths from fever ranged from 5,000 to 9,000, but only a small proportion was due to malaria, and as has already been remarked, when a new system of death registration was instituted in 1902 and enquiry into the cause of death was made by trained medical officers, the recorded fever mortality dropped immediately to 4,518 in 1902 and 2,333 in 1903.

92. *Total Fever Mortality.*—For the purpose of the present investigation the record of deaths from fever is of some importance. Unfortunately as is well known the term "fever" commonly used in India denotes no definite disease but relates to many different conditions.

The annual mortality recorded under the head of "Fever" in Bombay during the past thirty years is as follows :—

1879	...	8,445	1895	...	6,404
1880	...	7,513	1896	...	8,776
1881	...	6,437	1897	...	6,951
1882	...	5,453	1898	...	4,114
1883	...	5,903	1899	...	5,063
1884	...	6,830	1900	...	7,928
1885	...	6,648	1901	...	7,921
1886	...	5,820	1902	...	4,518*
1887	...	5,612	1903	...	2,500
1888	...	6,642	1904	...	2,530
1889	...	7,266	1905	...	2,878
1890	...	6,480	1906	...	4,882
1891	...	6,837	1907	...	3,633
1892	...	7,751	1908	...	3,403
1893	...	5,884	1909	...	2,800
1894	...	6,458	1910	...	2,793

93. The total deaths recorded under the heading of "fever" among different race during the past ten years are as follows :—

	1900.	1901.	*1902.	1903.	1904.	1905.	1906.	1907.	1908.	1909.
Hindus ...	6,045	6,484	3,299	1,560	1,573	2,010	3,735	2,604	2,351	1,874
Mussulmans	1,423	1,025	809	443	522	574	783	690	681	578
Parsis	156	146	160	147	150	121	152	131	144	119
Jews	25	53	19	12	5	8	18	18	11	7
Native Christians ...	...	169	160	127	136	118	129	140	160	165
Europeans	...	32	54	30	19	30	18	29	39	32
Eurasians	...	7	15	7	6	10	41	11	12	16
Others	14	5	4	7	6	2	6	10	5	2

* A new method of Registration was introduced during this year.

Among the Parsi, Eurasian and European communities cases of illness with few exceptions are probably treated by qualified medical men, and the returns made by them will undoubtedly be more accurate than the guessed-at diagnosis relied upon in the vast majority of other cases.

94. The deaths from fever recorded as occurring in the different wards of the City for a number of years past has been as follows :—

Deaths from fever in different wards.

Wards.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.	1908.	1909.
A.	315	264	231	184	145	195	283	283	309	370
B.	1,628	1,689	730	647	663	587	817	623	634	424
C.	1,306	1,298	899	470	410	546	814	696	562	444
D.	641	604	376	218	226	219	371	282	271	217
E.	2,638	2,726	1,342	535	726	965	1,864	1,196	973	854
F. ...	766	833	437	113	127	160	314	278	292	259
G.	634	496	501	156	111	163	387	238	236	182
Harbour, Docks, Railways and Homeless ...	5	11	11	10	8	13	32	37	36	50
Total ...	7,928	7,921	4,518	2,333	2,416	2,878	4,882	3,633	3,403	2,800

95. The following table gives the recorded mortality from different kinds of fever during the past ten years :—

	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.	1908.	1909.	1910.
Simple continued Fever	45	113	99	...	...	...	...	...	...	...	...
Enteric Fever	60	62	89	45	55	60	134	116	111	92	93
Ague	545	580	483	} 2,288	2,361	2,311	3,814	2,951	2,706	2,322	2,346
Remittent Fever ...	7,278	7,266	3,847								
Relapsing Fever ..	...		...	167	114	240	744	417	255	93	61
Malaria	...	...	...	...	...	267	190	149	331	293	293
Total ...	7,928	7,921	4,518	2,500	2,530	2,878	4,882	3,633	3,403	3,800	2,793

A consideration of the figures shows that it is hopeless to attempt to draw any conclusion from them regarding the prevalence of malaria in different years. The nomenclature used is also responsible for considerable confusion of ideas as may be seen by a remark in the Chapter on "Health" in the recent Gazetteer of Bombay City (Vol. III, p. 173) where it is stated that—

> "Tarwadi and Byculla *have a very low death-rate from Malaria, but "are notorious for the prevalence of Ague and Remittent fever** which are "due possibly to the fact that these areas are not properly drained and "contain many cesspools."

96. *Recorded mortality from Malaria.*—In 1903 the deaths from ague and remittent fever, which had previously been shewn separately in the mortality returns for the City, were pooled and in 1904 a special table for malaria, as distinct from ague and remittent fever, was published in the Annual Health Report. Since then a similar table has appeared each year, and ague and remittent fever have been shewn separately in Health returns as "fevers other than malaria." The following figures have been extracted from the special tables for "malaria":—

Mortality from Malaria by months, quarters and years, as recorded in the Health Reports of Bombay.

	1904.	1905.	1906.	1907.	1908.	1909.	1910.
January ...	26	27	14	13	17	20	18
February ...	27	30	23	12	16	25	21
March ...	26	16	17	18	22	29	25
1st quarter ...	79	63	54	43	55	74	64
April ...	20	17	1[illegible]	9	20	14	13
May ...	17	15	19	9	15	12	17
June	22	25	16	11	9	16	12
2nd quarter ...	59	57	41	26	44	42	42
July ...	19	16	15	7	20	9	33
August ...	20	11	7	7	17	24	23
September ...	24	29	8	8	14	28	24
3rd quarter ...	63	56	30	22	51	61	80
October ...	23	34	14	20	81	37	37
November ...	22	24	22	23	60	50	41
December ...	24	23	19	15	30	29	29
4th quarter ...	69	81	55	58	171	116	107
Total of year ...	270	257	180	149	331	293	293

Mortality from Malaria by Wards.

	1904.	1905.	1906.	1907.	1908.	1909.
Ward A. ...	16	35	29	33	77	72
„ B. ...	125	95	71	35	133	71
„ C. ...	37	74	40	33	41	45
„ D. ...	13	11	11	17	38	20
„ E. ...	59	47	24	19	35	51
„ F. ...	16	3	7	5	5	11
„ G. ...	1	1	6	7	6	6
Harbour, etc. ...	3	1	2	...	6	17

* The italics are mine.—C. A. B

Unfortunately these records are quite unreliable, and though the deaths returned as occurring in F. and G. wards, in which there is little or no malaria, may be near the truth, those returned from A., B. and C. wards are far below the actual, particularly since 1906. In 1908 it is probable that the actual deaths from malaria in A. ward alone exceeded the total number returned as occurring in the whole City. Of the 77 deaths from malaria recorded from this ward in 1908, 30 occurred in North Fort and 35 in Esplanade, but there are strong grounds for believing that the mortality from malaria in October alone in these two sections was considerably more than this. Of the 133 deaths from malaria recorded from B ward, 53 were reported from Dongri and only 27 from Mándvi. Dongri is a section in which there is comparatively little malaria but Mándvi was very seriously affected, and there is reason to suppose the mortality from malaria was very high there in 1908.

97. *Deaths at Seasons indicating Malarial mortality.*—Owing to the fact that the population of Bombay fluctuates both from year to year and from season to season, it is difficult to estimate by indirect means the probable number of deaths from malaria in any year; but there are two well recognized facts relating to the mortality produced by this disease which may assist us in gaining some idea of the deaths produced by it in Bombay. Malaria as is well known is a seasonal disease, and numerous observations shew that it usually attains its maximum intensity, as indicated by the co-incident mortality, in October or November, in other words immediately after the rainy season; and it takes the largest toll of human life from among young chidren under the age of 5 years.

98. If we take the case of Esplanade section which has suffered severely from malaria recently we find the total mortality recorded each month for the past few years to be as follows:—

	1903.	1904.	1905.	1906.	1907.	1908.	1909.
January ...	41	55	58	37	29	61	61
February ...	47	56	71	45	53	81	71
March ...	54	62	73	77	72	87	87
April ...	46	49	45	124	67	81	83
May ...	30	44	49	60	32	71	46
June ...	19	32	38	37	35	41	42
July ...	21	27	19	37	32	35	30
August ...	23	40	38	46	44	48	40
September ...	27	40	32	32	51	54	61
October ...	29	29	24	24	67	98	48
November ...	30	25	31	56	63	66	55
December ...	42	45	44	60	66	75	55
Total ...	409	503	522	635	621	801	679
1st half year ...	237	298	334	380	288	425	390
2nd „ ...	172	205	188	255	323	376	289

It will be noticed that the mortality in October 1908 exceeded that of any other month in the year and was nearly four times the mean of the October mortality in the years 1904-1906.

Taking October and November mortalities together we get the following totals:—

1903.	1904.	1905.	1906.	1907.	1908.	1909.
59	53	55	80	110	164	103

As it is well known that malaria in India almost always reaches its maximum in October and November, and as Esplanade section has been and still is severely affected by malaria, it may be assumed that in October and November 1908 the disease occasioned about 100 deaths more than the normal.

The total deaths from malaria since 1904 in Esplanade section recorded in the Health reports are as follows:—

	1904.	1905.	1906.	1907.	1908.	1909.
Total ...	1	8	6	9	53	31
Deaths from malaria in October and November...	...	...	2	4	17	11

99. For the North Fort which is also severely affected by malaria the monthly mortality figures are as follows:—

	1903.	1904.	1905.	1906.	1907.	1908.	1909.
January ..	179	115	125	109	101	77	90
February ...	189	141	197	127	120	95	86
March ..	191	138	186	185	126	123	134
April ..	204	115	140	173	101	128	119
May .	125	72	151	137	70	118	93
June .	91	70	96	86	59	96	64
July ..	75	52	72	80	66	64	59
August ..	76	78	70	95	111	74	73
September ..	60	91	76	96	100	79	71
October ..	65	77	73	96	91	103	80
November ..	67	72	73	102	96	93	74
December ..	81	76	89	92	84	96	90
Total ...	1,403	1,097	1,348	1,378	1,125	1,144	1,033
1st half year ...	979	651	895	817	577	635	586
2nd „ ...	424	446	453	561	548	509	447

As in the Esplanade so in the North Fort the October mortality in 1908 shewed a considerable rise above the normal. There are grounds for supposing that the North Fort has been more or less malarious for many years, but it is probable that a much larger proportion of the poorer inhabitants living there obtain treatment when sick, than is the case in the Esplanade section; and if this is the case it would materially lessen the rise of mortality in October.

The October and November mortality in the North Fort since 1903 has been as follows:—

1903.	1904.	1905.	1906.	1907.	1908.	1909.
132	149	146	198	187	196	154

It is probable that the increase of nearly 50 deaths a year at this period since 1905 has been due to malaria, occurring chiefly among the untreated portion of the population.

The deaths from malaria in the North Fort recorded in the Health reports for the past six years are as follows:—

	1904.	1905.	1906.	1907.	1908.	1909.
Total ...	12	21	17	17	30	29
October and November ...	5	3	6	5	12	6

100. The monthly mortality figures for Mándvi section which has also suffered considerably from malaria in recent years are as follows :—

	1903.	1904.	1905.	1906.	1907.	1908.	1909.
January ...	255	185	240	169	137	103	100
February ...	269	227	319	206	160	100	116
March ...	350	271	300	306	220	168	183
April ...	323	233	288	388	174	172	148
May ...	196	163	281	278	114	139	99
June ...	131	125	143	151	105	115	72
July ...	134	144	93	147	110	92	66
August ...	139	148	116	144	120	122	89
September ..	150	185	106	141	135	129	98
October ...	131	164	110	131	152	178	125.
November ...	126	161	106	114	114	121	86
December ...	142	163	152	131	120	127	127
Total ...	2,346	2,169	2,254	2,306	1,661	1,566	1,309
1st half year ...	1,524	1,204	1,571	1,498	910	815	718
2nd „ ...	822	965	683	808	751	769	591

As in Esplanade and North Fort sections so in Mándvi there was a considerable rise in mortality in October 1908, the highest mortality of the year occurring in this month ; and there is no doubt that the figure would have been much higher but for the fact that several thousand people were displaced from the malarious area owing to demolition of house property in 1908.

The totals of the joint October and November mortalities for the past seven years in Mándvi are as follows :—

1903.	1904.	1905.	1906.	1907.	1908.	1909.
257	325	216	245	266	299	211

There appears to have been a gradual increase of mortality at this season each year from 1905, and it is probable that this increase represents in part the effect that malaria has had upon this section in recent years.

The mortality from malaria in Mándvi recorded in the Health reports is as follows :—

	1904.	1905.	1906.	1907.	1908.	1909.
Total ...	28	35	35	3	27	4
October and November ...	4	12	0	1	18	3

Of the 35 deaths reported in 1906, 29 occurred between January and June and only 6 between July and December.

It is probable that the deaths actually due to malaria in 1908 were nearer 150 than the 27 recorded and it is certain there were many more deaths from this cause in 1907 and 1909 than 3 and 4, the totals given above.

101. Owing to the displacement in recent years of very large numbers of the people residing in Dhobi Taláo, Market and other sections of the City no conclusions can be drawn from the monthly mortality returns for these areas, and reference to them is therefore omitted.

102. *Deaths among children indicating Malarial mortality.*—It is now generally recognized that malaria produces a greater mortality among young children under 5 years and aged people than among adults between these ages. Reference to the following table, which gives particulars of the deaths at different age periods, etc., during 1907, 1908 and 1909, shows that during 1908, a year in which malaria was epidemic in certain parts of Bombay, there

was a considerable rise in the deaths among young children below five years of age :—

Ages.	Population at Census, 1906.	Total deaths at different age periods.			Death-rate per 1,000 at different age periods.			Percentage of deaths at age periods to total deaths.		
		1907.	1908.	1909.	1907.	1908.	1909.	1907.	1908.	1909.
Under 1	13,027	8,276	9,077	8,030	635·29	696·78	616·41	21·39	23·71	23·02
1—5	56,748	3,670	4,173	2,972	64·67	75·53	52·37	9·48	10·90	8·52
5—10	70,009	1,352	1,403	1,201	19·31	20·11	17·25	3·49	3·67	3·46
10—15	85,762	1,888	1,698	1,573	22·01	19·79	18·34	4·38	4·42	4·51
15—20	101,559	3,275	3,152	2,833	31·26	31·03	27·89	8·46	8·23	8·12
20—30	282,817	7,268	6,476	6,329	25·69	22·89	22·37	18·78	16·92	18·14
30—40	195,284	4,605	4,128	4,050	23·58	21·13	20·73	11·90	10·96	11·61
40—50	99,143	2,883	2,574	2,664	29·07	25·96	26·87	7·45	6·72	7·63
50—60	43,872	2,456	2,471	2,334	56·36	56·71	53·56	6·34	6·45	6·69
Over 60	26,574	3,005	3,080	2,874	113·08	114·32	108·15	7·76	7·93	8·24
Unspecified ...	3,327	9	10	12	2·7	3·0	3·6	·02	·02	·03
Total ...	977,622	38,637	38,271	34,878	39·56	39·13	35·66	100·0	100·0	100·0

Had the population of the City possessed an age distribution similar to that of the Presidency, this increased mortality among young children would have reached a total of more than 2,500 deaths.

103. The deaths among young children under 1 year and under 5 years of age in the different wards of the City since 1902 has been as follows :—

	1902.	1903.	1904.	1905.	1906.	1907.	1908.	1909.
A. Ward.								
Under 1 year	461	415	425	547	535	458	615	410
1—5 „	182	214	144	202	246	191	225	157
Total ...	643	629	569	749	781	639	840	567
B. Ward.								
Under 1 year	2,159	1,866	1,839	2,118	2,014	1,546	1,556	1,277
1—5 „	819	771	696	904	871	688	770	530
Total ...	2,978	2,637	2,535	3,022	2,885	2,234	2,326	1,807
C. Ward.								
Under 1 year	1,985	1,813	1,764	1,998	1,861	1,569	1,580	1,517
1—5 „	753	916	696	832	814	726	739	567
Total ...	2,738	2,729	2,460	2,830	2,675	2,295	2 319	2,814
D. Ward.								
Under 1 year	761	734	730	866	916	731	769	699
1—5 „	357	365	289	332	397	389	327	275
Total ...	1,118	1,099	1,019	1,198	1,103	1,110	1,096	974
E. Ward.								
Under 1 year	2,700	2,457	2,619	3,195	3,433	2,433	2,697	2,399
1—5 „	1,085	1,127	902	1,441	1,749	1,077	1,237	827
Total ...	3,785	3,584	3,521	4,636	5,182	3,510	3,934	3,226
F. Ward.								
Under 1 year	740	719	762	894	1,118	786	955	814
1—5 „	297	326	237	369	609	327	393	270
Total ...	1,037	1 045	999	1,263	1,727	1,113	1,338	1,084
G. Ward.								
Under 1 year	776	712	840	1,043	1,227	863	1,004	884
1—5 „	397	368	309	459	627	381	483	346
Total .	1,163	1,080	1,149	1,502	1,854	1,244	1,487	1,230

Unfortunately the fluctuation of the population from year to year influences these figures very greatly, and in the last few years the population in certain areas, notably in B., C. and D. Wards, has been greatly reduced owing to the demolition of many insanitary localities. Probably 40,000 people have been displaced in this way quite recently. But A. Ward has not been greatly influenced in this way, and the increased mortality among children in that ward in 1908 is undoubtedly due to the influence of malaria. It is probable that at least 300 young children under the age of 5 fell victims to malaria in A. Ward during that year.

104. Examination of figures for smaller areas than wards brings out the following facts :—

Mortality of Young Children.

	1902.	1903	1904.	1905.	1906.	1907.	1908.	1909.
Middle Colaba.								
Under 1 year	112	107	129	153	157	100	112	124
1—5 ,, ...	44	57	38	41	83	50	31	35
Total ..	156	164	167	194	240	150	143	159
Fort, North.								
Under 1 year	265	221	210	286	263	235	333	168
1—5 ,, ...	112	110	73	121	116	97	118	88
Total ...	377	331	283	407	379	332	451	256
Esplanade.								
Under 1 year	58	68	74	83	82	88	139	96
1—5 ,, ...	18	38	23	31	40	36	64	25
Total ...	76	106	97	114	122	124	203	121

It will be seen from the above table that in 1905 and 1906 there was a great increase of child mortality in Colaba. This increase appears to have been associated with the increased prevalence of "fever" in Colaba in those years, an increase shewn also by the rise in the number of cases treated at the local dispensary. Esplanade and North Fort shew a greatly increased child mortality in 1908 and there is no doubt that this was the result of the severe malaria prevalent in that year.

It is no use giving figures for other malarious sections such as Mándvi, Dhobi Taláo and Market, as very large displacements of population have occurred in all these areas which render the figures fallacious.

105. *Effect of malaria upon births, etc.*—It is well known that malaria exerts considerable influence in reducing the births and increasing the number of still-births and miscarriages that occur in a community. Unfortunately the registration of births is not supposed to be accurate in Bombay, and the shifting character of the population largely affects the number recorded as occurring in different localities from year to year. But it may be pointed out that in A. Ward which is very malarious, and where there appears to have been little change in the population in recent years, the total number of births has steadily fallen, as the following figures shew :—

A. Ward total births.

1902.	1903.	1904.	1905.	1906.	1907.	1908.	1909.
1,107	1,020	1,265	1,270	1,240	1,222	1,087	1,077

It may be remarked also, that as a whole, the births in portions of the City known to be malarious have either remained stationery or shew a slight decrease in recent years. During 1908 the ratio of still to live-births increased in the malarious areas as may be seen by the following figures :—

Ratio of still-births to 1,000 live-births.

	1906.	1907.	1908.	1909.
A. Ward ...	91	101	119	108
B. Ward ...	109	98	136	107

In particular there was a great increase in still-births in Esplanade section.

Ratio of still-births to 1,000 live-births in Esplanade.

1904.	1905.	1906.	1907.	1908.	1909.
106	176	175	158	218	188

Esplanade section was the area most severely affected by malaria in 1908 and the above figures are important in view of this fact.

106. Before leaving the question of malaria and its effects in reducing births, increasing still-births and miscarriages and diminishing the natural increase of population, it may be pointed out that the birth-rate among Pársis, who as a race shew more evidence of chronic malaria than any other community in Bombay, has been exceedingly low for many years. The Pársi birth-rate has only once reached 30 per 1,000 in 1888; for long periods their total births have only exceeded the deaths by a small number, the maximum excess of births over deaths having only once approached 6 per 1,000; and for a number of years the deaths have exceeded the births.

A large proportion of the total Pársi population live in the North Fort and Dhobi Talão, which are two of the most malarious sections of the City; many Pársi families reside in houses which contain open wells infested with the malaria-carrying anopheles *Neocellia stephensi* and many of them suffer from chronic malaria; and in view of these facts the lack of increase in the Pársi population of Bombay is most significant.

Section 4.

107. MALARIA AS A CAUSE OF SICKNESS IN BOMBAY.—The earliest records of sickness in Bombay do not suggest that malaria was a very serious cause of morbidity 150 years ago. Judging by the hospital returns for January 1774, quoted in another paragraph, only about 10 per cent. of the total cases under treatment were admitted to hospital for "fever." But at a later period the disease became more common, as may be seen by a table quoted in Davidson's Diseases of Warm Climates in 1893. This table which gives the mean number of admissions for intermittent, remittent and continued fever per 1,000 of strength among British troops at different stations in India for a series of years is as follows:—

Admissions.	Lahore.	Peshawar.	Bombay.	Saugor.	Meerut.	Agra.	Lucknow.	Fort William.	Madras.
Intermittent ...	1406·0	1119·3	917·3	703·1	574·5	278·0	122·1	117·2	39·7
Remittent and continued fever.	48·7	717·8	94·5	169·3	126·7	181·0	168·2	166·5	116·6

Unfortunately the years to which these figures refer are not given, so that it is impossible to learn the period to which the table relates.

108. The admissions for ague and intermittent fever among British and Native troops stationed in Bombay since 1896 have been as follows:—

British Troops.

Years.	Average annual strength.	Total admission for ague.	Ratio per 1,000 of strength admitted for ague.
1896	1,212	107	88·3
1897	1,128	268	237·6
1898	1,200	168	140·0
1899	1,266	227	179·3
1900	1,164	173	148·6
1901	1,240	241	194·4
1902	1,322	154	116·5
1903	1,333	205	153·8
1904	1,296	142	109·6
1905	1,268	233	183·8
1906	1,122	256	228·2
1907	1,056	240	227·3
1908	1,152	392	340·3
1909	1,055	304	288·2

Native Troops.

Years.	Average annual strength.	Total admission for ague.	Ratio per 1,000 of strength admitted for ague.
1896	1,255	257	204·8
1897	1,383	249	180·0
1898	1,213	303	249·8
1899	1,232	271	220·0
1900	1,234	318	257·7
1901	1,264	522	413·0
1902	1,167	329	281·9
1903	1,301	391	300·5
1904	1,005	323	321·4
1905	720	271	376·4
1906	554	261	471·1
1907	586	232	395·9
1908	648	330	509·3
1909	711	235	330·5

It will be seen from these figures that malaria has not produced a very great amount of sickness among British troops in Bombay City. And although there was a considerable rise in the admission rate between 1907-1909, the increase cannot be attributed to local causes entirely, as during this period a regiment that had been stationed in Lahore Cantonment (Mian Mir) was drafted to Bombay. The situation of the Bombay Cantonment (Colaba) for British troops is an excellent one, and there is little evidence to shew that malaria is contracted in that locality, which appears to be wonderfully free from sources of infection.

The admission rate for "intermittent fever" among Native troops in Bombay is much higher than that among British troops. This is probably due mainly to the fact that the barracks of the Native troops are situated in parts of the City which have been shewn to be malarious. The Native Infantry Lines at Paltan Road are within the area that has been influenced by the new dock-works and the larger barrack at Marine Lines adjoins Dhobi Taláo section, which is seriously affected by malaria on account of the number of open house wells infested with *Neocellia stephensi* which are present there. It will be seen that, in spite of good housing and regular treatment, the Native troops suffered from malaria in 1908 in the proportion of over 500 per 1,000 of strength.

109. The following table gives the total admissions for supposed malaria in a number of medical institutions in Bombay for a series of past years :—

Year.	Number of Hospitals and Dispensaries.	Number of admissions.	Number of malaria cases.	Percentage.
1890	7	96,697	9,911	10·2
1891	10	109,372	13,264	12·1
1892	11	112,959	13,723	12·1
1893	11	106,316	13,174	12·4
1894	11	119,911	13,424	11·2
1895	11	108,947	13,597	12·5
1896	11	79,411	8,417	10·5
1897	11	71,742	4,345	6·05
1898	11	83,019	6,170	7·4
1899	11	100,459	9,811	9·7
1900	10	90,580	10,190	11·2
1901	17	153,486	23,597	15·3
1902	29	209,013	34,217	16·3
1903	29	207,654	38,148	18·3
1904	22	372,492	48,539	13·03
1905	21	381,030	46,461	12·2
1906	21	369,799	51,181	13·8
1907	21	337,613	55,364	16·4
1908	20	341,684	63,938	18·7
1909	21	358,765	54,839	15·3

From this table it would appear that in recent years only about 50,000 cases of supposed malaria have been admitted annually to dispensaries and hospitals in Bombay and this number represents only from 12 to 18 per cent. of the total cases treated. But these figures give no true indication of the total amount of sickness produced by the malaria in the City.

110. If we examine the returns from the Police Hospital since 1901 we get the following figures :—

Year.	Total admissions for sickness.	Admission for fever.	Percentage.
1901	1,885	1,095	58·0
1902	1,886	953	50·5
1903	1,670	815	48·8
1904	1,803	897	49·1
1905	1,938	1,034	52·3
1906	1,901	890	46·8
1907	1,919	913	47·5
1908	2,502	1,626	64·9
1909	2,488	1,455	58·4
1910	2,204	1,157	50·2
Average ...	2,196	1,083	49·3

It will be seen from this table that nearly 50 per cent. of the total admissions from among about 2,000 police stationed in all parts of Bombay are due to febrile disease. Dr. Powell's observations in 1901-1903 shewed the presence of malarial parasite in 75 per cent. of all cases, so that it is probable that the average admission rate for malaria among the police in Bombay is not less than 376 per 1,000 per annum.

111. In 1908 of the total admissions for "fever" among the police, the following percentages came from the different wards in the City :—

A. Ward	...	42·1 per cent.
B. „	...	29·5 „
C. „	...	10·2 „
D. „	...	6·0 „
E. „	...	6·4 „
F. „	...	3·3 „
G. „	...	2·1 „

Over 80 per cent. of the cases of malaria were drawn from A., B. and C. Wards, rather more than 12 per cent. from D. and E. Wards, and only 5·4 per per cent. from F. and G. Wards. These figures support in a remarkable way the conclusions regarding the distribution of malaria on the island of Bombay arrived at as a result of the spleen census and blood examination.

112. From the following table which gives more detailed particulars of the admissions of fever at a number of dispensaries in the City, it will be seen that the percentage of admissions recorded in various institutions in different parts of the City during a series of years have ranged as low as 1·5 per cent. and as high as 64·9 per cent.

Details of admissions to different medical Institutions in Bombay.

		1903.	1904.	1905.	1906.	1907.	1908.	1909.	1910.
No. 1.									
Frere Road Municipal Dispensary...	Total cases ...	5,014	6,605	8,367	10,160	11,420	11,686	8,158	7,951
	Fever cases ...	2,074	2,984	4,086	4,852	6,584	7,173	4,240	4,014
	Percentage ...	41·3	45·1	48·5	47·7	57·6	61·5	51·9	50·4
No. 1.									
Colaba Municipal Dispensary ...	Total cases ...	7,993	7,123	7,244	10,146	8,187	7,329	7,334	6,335
	Fever cases ...	2,676	2,958	2,559	4,357	3,478	3,129	3,156	2,055
	Percentage ...	33·4	41·5	35·3	42·9	42·4	42·6	43·0	32·4
No. 2.									
Kolsa Mohalla Municipal Dispensary.	Total cases ...	4,266	5,495	4,220	4,002	3,870	3,874	4,246	4,549
	Fever cases ...	1,132	1,346	1,193	1,034	109*	427*	709*	538*
	Percentage ...	26·5	24·5	25·9	25·8	2·8*	11·0*	16·6*	11·8*
No. 3.									
Umarkhadi Municipal Dispensary ...	Total cases ...	11,575	13,134	13,075	12,773	11,315	10,218	9,803	9,632
	Fever cases ...	3,323	2,916	3,426	4,123	3,382	3,016	961*	785*
	Percentage ...	28·6	22·2	26·2	32·3	29·8	29·4	9·7*	8·1*
No. 4.									
Cathedral Street Municipal Dispensary.	Total cases ...	2,016	2,807	2,078	3,057	3,062	3,644	3,804	4,994
	Fever cases ...	390	509	454	635	495	289*	1,020	960
	*Percentage ...	19·3	18·1	21·8	20·77	16·1	7·9*	26·5	19·2
No. 5.									
Grant Road Municipal Dispensary...	Total cases ..	10,104	9,372	10,142	8,744	8,355	8,039	10,127	20,391
	Fever cases ...	1,580	1,356	1,284	1,473	1,494	1,447	713*	1,102*
	Percentage ...	15·5	14·4	12·6	16·8	17·8	17·9	7·0*	5·4*
No. 6.									
Kandewadi Municipal Dispensary...	Total cases ...	3,768	4,135	3,948	4,042	4,656	4,533	4,360	3,763
	Fever cases ...	1,242	1,290	1,425	1,526	1,601	1,401	1,365	792
	Percentage ...	32·9	31·1	36·0	37·7	34·3	30·8	31·5	21·4
No. 7.									
Belasis Road Municipal Dispensary.	Total cases ...	15,502	17,826	15,925	15,898	12,318	9,374	10,980	10,370
	Fever cases ...	2,754	2,159	1,472	1,014	930	625	481*	163*
	Percentage ...	17·7	12·1	9·2	6·3	7·6	6·6	4·3*	1·5*
No. 8.									
Foras Road Municipal Dispensary...	Total cases ...	11,006	10,044	11,501	10,744	9,401	9,910	8,875	7,372
	Fever cases ...	1,278	749	2,138	2,301	1,893	1,606	1,560	867
	Percentage ...	11·6	7·4	18·5	21·41	20·1	16·1	17·7	11·7
No. 9.									
Elphinstone Road Municipal Dispensary.	Total cases ...	5,271	5,000	5,380	5,664	4,929	4,409	6,259	8,434
	Fever cases ...	319	403	274	358	393	670	551	779
	Percentage ...	6·0	8·0	5·0	6·32	7·9	15·1	8·8	9·2
No. 10.									
DeLisle Road Municipal Dispensary	Total cases ...	16,286	15,013	15,050	13,625	11,416	11,638	10,895	10,991
	Fever cases ...	2,522	2,644	2,543	2,161	1,680	1,534	725*	600*
	Percentage ...	15·4	17·6	16·8	15·8	14·7	13·1	6·6*	5·4*
Northcote Police Hospital ...	Total cases ...	1,670	1,803	1,938	1,901	1,919	2,502	2,488	2,204
	Fever cases ...	815	897	1,034	890	913	1,626	1,455	1,127
	Percentage ...	44·8	49·1	52·3	46·8	47·5	64·9	58·4	52·4
Jaffer Suleman Dispensary ...	Total cases ...	...	...	8,266	7,773	7,227	8,173	9,203	8,667
	Fever cases ...	...	...	448	466	408	1,082	1,651	863
	Percentage ...	...	...	5·4	5·9	5·6	13·2	17·9	9·9
Port Trust Dispensary	Total cases ...	4,018	4,325	4,198	4,435	4,137	4,739	5,426	5,980
	Fever cases ...	1,001	1,204	1,168	1,105	1,255	2,120	2,237	2,287
	Percentage ...	24·9	27·8	27·8	24·9	30·3	44·7	41·2	38·2
Railway Dispensaries	Total cases ...	24,436*	192,220	190 631	192,558	175,992	180,591	182,980	...
	Fever cases ...	8,125*	21,610	18,958	19,025	25,260	31,357	25,936	...
	Percentage ...	33·0*	11·2	9·9	9·8	13·1	17·3	14·1	...
Mahim Dispensaries	Total cases ...	5,722	6,317	6,463	6,509	6,041	6,648	6,656	...
	Fever cases ...	1,657	1,848	1,690	1,982	1,713	2,077	2,035	...
	Percentage ...	28·9	29·3	26·1	30·4	28·3	31·2	30·5	...

* These low figures are very doubtful.—C. A. B.

Unfortunately some of the figures have to be accepted with reserve, notably when a sudden and unaccountable fall in the fever cases has occurred. In No. 2 District Dispensary the fall in fever cases from 25·8 per cent. in 1906 to 2·8 per cent. in 1907 denotes either an error or a change in the method of recording

admissions. A similar change is seen in the figures for No. 4 District dispensary where a sudden fall from 20·7 per cent. and 16·1 per cent. to 7·9 per cent. is recorded in 1908, the fever admissions rising to 26·5 in 1909. From some of the dispensaries two sets of figures have been obtained, one showing a fairly high percentage of fever admissions and the other a lower one and it has been found impossible to ascertain which is the correct one. Some confusion appears to have been caused by the attempt to notify cases of "supposed malaria" separately in some institutions and to include them among general admissions for "fever" in others. In the case of the Railway dispensaries it is quite obvious that the introduction of some change in the method of recording all admissions in 1904 has been responsible both for the enormous increase of patients treated and the great fall in the proportion of fever cases. In the appendix, tables are given showing the monthly admissions to a number of the dispensaries mentioned above.

113. It may be remarked that one of the arguments originally put forward in support of the establishment of Municipal Free Dispensaries was the suggestion that they would give valuable indications of the presence of epidemic and other diseases in the City. There is little question that the dispensaries might easily serve as indicators of the prevalence of sickness; and if their sick returns were carefully systematized and in the case of fever admissions a correction factor was established by the careful examination of some hundreds of blood specimens from each dispensary, much valuable information would be gained from year to year, which among other things would be of great service in estimating the effects of anti-malarial measures.

114. During the course of the special investigation 1,001 blood specimens obtained from fever cases admitted to a few of the hospitals and dispensaries of the City were examined microscopically, and the results obtained are recorded in the following table :—

Cases of fever from different localities in the City.

Ward.	Number examined.	Number infected.	Percentage infected.
Ward A.	338	180	53·2
„ B.	155	63	40·6
„ C.	134	39	29·1
„ D.	60	23	38·3
„ E.	290	83	28·6
„ F. and G. ...	24	10	41·6
Total ...	1,001	398	39·7

It must be remembered that the percentage of infection found in these cases by an examination of 150 microscopic field represents only about two-thirds of the actual which would probably be as follows :—

Ward A.	79·8	per cent.	infected.
„ B.	60·9	„	„
„ C.	43·6	„	„
„ D.	57·4	„	„
„ E.	43·2	„	„
„ F. and G. ...	62·4	„	„
Total ...	59·5	„	„

From these figures we are justified in assuming that malarial parasites are present in from 43 to 80 per cent. of the cases of fever diagnosed as malaria in Bombay.

But there are considerable differences to be observed in the proportion of infected cases obtained from different parts of the island, and this fact emphasizes the necessity for making similar observations in connexion with each dispensary, so that the figures obtained may be used as correction factors for testing the statistics of admissions.

CHAPTER III.

115. EPIDEMIC MALARIA IN BOMBAY.—Before discussing epidemic malaria in Bombay it must be pointed out that there is no evidence to shew that outbreaks of malaria on that island have ever been of so severe a nature as the pandemics that occur in the Punjáb and other parts of India, and the term "epidemic malaria" applied to conditions met with in Bombay refers merely to an increase of the disease above the normal, due in the most part to the occurrence of local outbreaks or epidemics.

The medical history of Bombay is so obscure that it is exceedingly difficult to get any definite history of epidemic outbreaks of malaria in the past. In 1757 a severe epidemic of some sort occurred both among the labourers employed upon the fortifications and the general population. It is not certain that the disease was malaria, but in view of the nature of the work and the locality (*i. e.*, the fort which was surrounded by the moat and contained many private and public wells), it is probable that the outbreak was of this nature. An epidemic of malaria took place in Colaba about 1838-1841. This outbreak appears to have occurred in association with the construction of the Colaba Causeway. The work on the Colaba Causeway which began in 1835 involved the reclamation of a large area of low-lying land previovsly covered by the sea at certain states of the tide. Colaba became comparatively healthy again after the completion of the Causeway, a result which is in accord with the general experience of such outbreaks.

116. There appears to have been an outbreak of fever in Bombay during the period of extraordinary commercial activity between 1861-1866 which followed upon the inflation of cotton prices as a result of the American War. A large number of reclamation schemes were commenced in different parts of the island at this time and they were probably responsible for an increase of malaria. In particular the Back Bay Reclamation, which was begun and then allowed to remain for some time uncompleted, appears to have given rise to a considerable increase of malaria in the areas immediately adjoining it. The increased prevalence of fever is shewn by the fact that during the four years 1863-1866 the fever deaths recorded in the City averaged 12,577 a year, or nearly double the mean of the previous five years, and in 1865 the recorded fever mortality reached a maximum of 18,767.

117. Ten years later the proposal to construct the Prince's Dock occasioned considerable alarm owing to the fear that it would affect the health of the City. Work was begun in 1875 and the Dock was completed in 1880. In spite of the fears expressed by many people before the commencement of the work, no special outbreak of fever appears to have been associated with it. It is true that in 1877-1878 fever became prevalent in Bombay, but this was due to the influx of large numbers of famine-stricken people from the rural districts; and the fever prevalent then was shewn by Vandyke Carter, who investigated the condition, to be "famine fever" or relapsing fever, a disease entirely distinct from malaria. On several occasions local outbreaks of malaria appear to have occurred at different times in connection with the construction of the water-works at Malábár Hill and also in connection with similar work at Bhandárwáda Hill, Mazagaon.

118. When the construction of the Victoria Dock and Merewether Dry Dock was undertaken no outbreak of malaria appears to have occurred; neither did the enlarging of the Duncan Dry Dock and construction of a Wet Basin in the Government Dockyard, which was decided on in 1890, seem to give rise to any great measure of unhealthiness. But this latter work was pushed on very rapidly, 2,000 men being employed upon it, so that everything was completed in two and a half years from the commencement, and it is possible that a temporary increase of malaria may have been overlooked.

119. Between 1903 and 1907 there appears to have been a local increase of malaria at Malábár Hill in the neighbourhood of the water-works co-incident

with the enlarging of the filtering plant and reservoir; and similar work at Mazagaon also appears to have given rise once more to a temporary increase of the disease in that locality.

120. During the recent reclamation work at Colaba there was a marked increase of "fever" in that neighbourhood, which is reflected in the sudden rise of nearly 70 per cent. in the cases treated at the local dispensary; and the demolition work carried out by the Improvenent Trust in the areas required for Sandhurst Road, Princess Street and for the reconstruction of areas such as Dongri-Koliwáda also appears to have caused local increases of malaria in those localities.

121. The construction of the Alexandra Dock and Hughes Dry Dock, which is still in progress, has caused a considerable increase of malaria in the areas adjoining it. Work on these docks was commenced in 1904. A large number of labourers are employed and many of those engaged on the excavation work have from the first resided in huts erected on the site of the work. An increase of "fever" occurred in the neighbourhood of Frere Road in 1905, but it was not until the end of 1907 that residents in the vicinity began to complain. In 1908 the disease broke out with increased severity and as a result there was an exodus of coolies and labourers employed in the neighbourhood of the docks and among the shipping. The 1908 outbreak caused a considerable outcry and it was stated by many people at the time that the dock-work was entirely responsible for the presence of malaria in Bombay. But the abnormal increase of malaria was not confined to the area around the docks; for in parts of the City remote from the dock-works malaria was also more prevalent and more severe during 1908 than usual. On the other hand, at Sewri, where the Port Trust had large reclamation works in progress, and in the north of the island along the line of the new Harbour Branch Railway, which was undergoing construction at this time, there does not appear to have been any great increase of malaria. The latter work entailed a large amount of excavation and earthwork and many coolies were employed upon it, but neither the workmen nor residents in the vicinity of the new line appear to have suffered from malaria to any great extent.

122. Although the epidemic associated with the construction of the new docks affected a considerable area, including portions of Mándvi and Chakla, the Esplanade and to some extent the North Fort, the suggestion made in 1908 that practically all the malaria in Bombay was due to these works is not in accord with facts.

123. It is not difficult to map out the area influenced by direct diffusion of infection from the new dock-works. To the immediate north of the new dock enclosure lies Carnac Bandar with Victoria Dock beyond it. The most southerly berths in Victoria Dock are used by the P. & O. Company; and during the epidemic in the summer of 1908 the crews of many of the P. & O. vessels lying there contracted malaria. On boat after boat from 80 to 100 cases of the disease occurred among the crew during the homeward voyage. It was only members of the crew who remained on board while the boats were in the dock who suffered; the passengers entirely escaped. But although the P. & O. crews suffered severely, other ships berthed in the Victoria and Prince's Dock, beyond the P. & O. boats, did not appear to be much affected and those ships which lay out in the harbour escaped almost entirely. In Mándvi section, which lies to the west of Victoria Dock, the disease penetrated some distance, but did not pass beyond Masjid Siding to any great extent. Further west it penetrated about half through Chakla, but the blocks of dwelling houses, many of which rise to five storeys in height, soon barred its progress. During the spleen census in 1909 it was found that high blocks of houses, separating two narrow streets in the middle of Chakla, shewed a high spleen rate reaching 20 per cent. among residents on the side facing the harbour; but among residents in the tenements facing away from the harbour the spleen rate was only about 3 per cent. In Esplanade section infection was diffused as far as Crawford Market; and the inmates of the Paltan Road Improvement Trust semi-permanent chawls, Municipal chawls and Native

Infantry Lines suffered severely. Large buildings such as the Crawford Market and Sitaram Buildings appear to have acted as a bar to the diffusion of infection, there being much less sign of malaria immediately due west of them than on the Paltan Road side; but, where the wall of high buildings ceased, infection diffused more deeply into the Esplanade and penetrated as far as the Cama Hospital, the Gokuldas Tejpal Hospital and St. Xavier's College. Further south in the Esplanade the lofty buildings of the Victoria Terminus and the Municipal Offices appear to have checked the diffusion of infection to the west, but all the residents to the east of these buildings suffered severely. The guards, porters and sweepers belonging to the G. I. P. Railway were attacked, and so many of the former were prostrated that at one time during the height of the epidemic as many as ten of the local trains had to be cancelled. St. George's Hospital, which is situated so that it overlooks the new dock-works, became the most malarious place in the City, the members of the nursing staff were frequently prostrated with malaria, and few of the patients who entered the hospital escaped contracting the disease. The portion of the North Fort immediately overlooking the harbour was also seriously affected, but a careful examination of that area shews that, though malaria was intense in Frere Road, there was a marked fall in the amount of infection present, as shewn by the spleen rate, in the area immediately adjoining Mint Road. This appears to indicate that blocks of high buildings in the North Fort formed a barrier and checked the diffusion of malarial infection from the east into that section just as they had evidently done in Chakla.

124. Passing westward from Fere Road into the North Fort, malaria becomes more intense again, but investigation has shewn that this is due not to the diffusion of malaria from the east or harbour side, but to the existence of hundreds of open wells and permanent foci of malarial infection in the Fort itself.

A similar centre of infection, due entirely to local causes, is to be found in Dhobi Talão section, an area situated on the west side of the island far away from the new dock-works. In this case also the local cause of malaria is the presence of hundreds of open house wells in the section; and the same influence may be traced in the Market section to the east of this.

125. It is now evident as a result of numerous observations regarding the distribution of splenic enlargement, malarial infection and local species of anopheles mosquitoes, that all the factors necessary for the continued existence and spread of malaria are to be found in many of the older portions of the City, especially in A. and parts of B. and C. Wards and to a much less extent in D. and E. Wards. And so long as this condition is allowed to exist, the undertaking of any large work necessitating excavation and leading possibly to the encampment for a considerable period of large bodies of coolie labourers on the site of the work, will undoubtedly be followed by a gradual increase of malaria in the adjoining areas, unless the strictest precautions are adopted from the outset.

126. There are strong grounds for believing that the absence of outbreaks of malaria in association with the construction of the Prince's and Victoria Docks years ago and the more recent work at Sewri and the Port Trust Railway was due to the fact that :—

(1) No serious centres of malarial infection existed in the vicinity of these works;

(2) Few permanent breeding places of dangerous species of anopheles were present in their neighbourhood;

(3) The labourers employed were not encamped, in the case of the dock-works, on the site of the works.

127. The sequence of events in connection with the epidemic outbreak of malaria associated with the construction of present new docks appears to have been as follows :—

(1) The existence of a serious amount of malarial infection among the residents of North Fort close to the site of the works.

(2) The existence of numerous permanent breeding places of *Neocellia stephensi* in the hundreds of open house wells and a less number of masonry tanks and iron cisterns in the North Fort, adjoining the area in which construction work was being undertaken.

(3) The settling down of many coolie labourers in temporary huts on the site of the new dock-works.

(4) The formation of many pools of water on the upper surface of the works (not excavations) in the vicinity of the labourers' huts.

(5) The gradual spread of *Neocellia stephensi* from the North Fort to these new breeding places.

(6) The gradual spread of infection among the labourers, at first chiefly from the North Fort but afterwards from one to another.

(7) The occurrence in 1907 and 1908 of climatic, economic and other conditions favouring an epidemic outbreak of malarial disease.

128. There is plenty of evidence to shew that malaria existed in the North Fort long before 1904 when the docks were commenced.

A medical man born and brought up in the Fort volunteered the information that he well remembers possessing an enlarged spleen as a boy and being treated for it; and ten years ago Europeans resident in flats near Elphinstone Circle repeatedly suffered from malaria, some of them so severely that they had to leave the neighbourhood.

As residents in the North Fort contracted malaria years ago, it is certain that the transmitting agent must have been present. *Neocellia stephensi*, the transmitting agent of most of the malaria in Bombay, was found in the city in 1901, and the presence of over 600 wells and other collections of water in the North Fort, 300 of which were infested with it in 1909, makes it reasonable to assume that it has been concerned in the spead of malaria in this area for a very long period.

129. The settling of large numbers of coolies in temporary huts on the dock site was a mistake in view of the danger of epidemic disease occurring amongst them. The rule that, in malarious countries labourers should not be housed on the site of large excavation works, was first laid down by Colin over 50 years ago and it has been endorsed by many other authorities since then.

Fayrer in 1902, emphasizing the precautions previously laid down by Colin, states :—

"The draining of marshes, the making of canals, railway cuttings, "roads, embankments, fortifications and such like, and the cutting down of "jungle, should be executed with great precautions, and if possible at the "healthy season; the labourers are to be protected by proper shelter, "*removal from the seat of labour at night*,* and the free use of quinine and "proper diet while they are at work."

It is probable that the failure to remove the labourers from the site of the work at night and the omission possibly of sufficiently drastic measures of prevention at the outset have been responsible for the severity of the outbreak of malaria in the neighbourhood of the new docks.

130. There is no reason to suppose that the labourers brought much infection with them, as the examination of newly arrived coolies living on the works has usually shewn them to be free both from enlarged spleen or parasites in their blood; but those resident a few months shew a considerable amount of infection; and among those over a year at work nearly everyone has an enlarged spleen. In 1910 the headman of one gang volunteered the statement that of 300 working coolies who came with him from their district (Márwár) one hundred had died and another hundred had deserted their work during the preceding eighteen months. He ascribed the occurrence of fever and enlargement of the spleen among his men to the water they drank at the docks and stated that in his own village the people did not suffer in this way. His ideas regarding the water were of course an error, but the examination of a dozen

* The italics are mine.—C. A. B.

people newly arrived from the same district shewed that none of them had splenic enlargement or other sign of malaria, a fact which supported his statement regarding the absence of malaria in his village.

131. The only conclusion that can be arrived at regarding the origin of the epidemic of 1908 is that, the existence of unrecognized centres of malarial infection in various parts of the City and a gradual and unsuspected increase of malaria in association with these centres was the prime cause of the outbreak and the determining factor was a combination of climatic, economic and other conditions favourable to the spread of malaria. Where these conditions could act with greatest effect, *i. e.*, in the area around the new dock-works and among the coolie labourers encamped there, they produced a more intense outbreak than in other parts of the City.

132. In view of this conclusion the question naturally arises :—

(1) Could the 1907-1908 epidemic of malaria have been prevented? and

(2) Is there a danger of other similar epidemics occurring in the future?

It is very doubtful if there could have been such an epidemic if there had been no more malaria in the Fort, Dhobi Talão and the southern portion of the City generally than there is in the centre and the extreme north of the island. If steps had been taken to thoroughly investigate the distribution of malaria on the island and the means by which it was spread after Powell had shewn the comparative frequency of the disease among the City Police in 1901 to 1903 there is little question that the conditions favouring an increase of malaria would have been recognized; and it is probable that, if it had been realized in 1904 that the North Fort was a focus of malaria, adequate precautions would have been adopted in connexion with the new docks at the outset.

As to the possible recurrence of epidemic malaria in Bombay, it may be remarked that, now that the facts are known and the danger recognized, there should be less chance of malaria being allowed to pass beyond control. But unfortunately malaria is far from being controlled at present. The small attempts that have been made to limit it have only served to mitigate the disease to a slight extent, and though it has been checked a little in some areas, unless more radical measures are adopted and carried to a successful termination, the City will remain as liable to epidemic outbreaks of malaria in the future as it has been in the past.

CHAPTER IV.

133. THE COST OF MALARIA IN BOMBAY.—It is always difficult to estimate the cost of a disease to a community, even when there are exact figures to go upon, because there are so many different factors to take into account. In cases of death there is the loss occasioned to relations, cost of burial, funeral ceremonies and expenses which are incurred in connexion with it; and there is also the loss of possibly useful lives to the community, representing capital of unknown amount. But when we come to estimate the loss occasioned by malaria, death is a small matter compared with sickness. Ross states that probably one-third of the total population of malarious countries require medical treatment on account of malaria every year and that probably from one-fourth to one-half of the total attendance at hospitals and dispensaries are due to this cause.

134. But in India the number of cases of malaria attending hospitals is no criterion of the total number of sick, and in a city like Bombay, where there are probably not less than 700 qualified medical men, a host of unqualified practitioners and many hundreds of chemists and druggists of all sorts, only a proportion of the total sick among the population attend hospitals and dispensaries. There are many people among the working classes also who do not think of seeking treatment until after they have suffered from repeated attacks of fever; and it is probable therefore that only a small proportion of the cases of mild "intermittent" malaria receive treatment of any kind. During the past ten years the supposed cases of malaria treated at certain of the hospitals and dispensaries in the City appear to have varied from about 15 to 18 per cent. of the cases treated. The total number of cases of all kinds receiving treatment is between 3,00,000 or 4,00,000, giving an admission rate for sickness on the whole population of nearly 400 per 1,000 per annum. But if we take the Police Hospital we find that the rate of admission per strength for all diseases is more than 1,000 per 1,000 of strength and of these admissions nearly 50 per cent. are cases of fever. During the years 1901-1903 the diagnosis of these fever cases, based upon a careful examination of the blood conducted by an expert, showed that 75 per cent. were due to malaria.

It is certain that there is at least as much sickness among the general population as among the police and probably a far greater amount; but if we estimate the rate to be the same we should have about 1,000,000 cases of sickness in Bombay each year. Of these cases half or about 500,000 will be cases of febrile disease, and of these "fever" cases 75 per cent. may be assumed to be malarial in nature. That is to say, on a very low estimate there are probably 375,000 cases of malaria in the City every year.

135. As about 60 per cent. of the population of Bombay are workers we may estimate that about 225,000 cases of malaria would occur among them and would result on the average in the loss of about a week of work in each case. Taking the average earnings of workers as at Rs. 20 a month (which is a low estimate) this would mean a loss of about Rs. 5 per case, either in wages to the worker or loss of work to the employer, and the total loss would be equivalent to Rs. 11,25,000. If we estimate a loss also of Re. 1 on every case of malaria occurring among non-workers, this would amount to another 1,60,000 of rupees, making a grand total of Rs. 12,85,000 per annum. In 1908 the loss was probably more than double this or nearly Rs. 30,00,000.

136. Or we may arrive at a figure in another way.

To take the Police, again, among whom the average admissions for "fever" are nearly 540 per 1,000 of strength per annum. The pay of the subordinate police including the cost of their free quarters may be put down at Rs. 15 per month or about 8 annas per day. Allowing one week off duty for each case of fever, which is a low estimate, about 1,100 weeks of duty are lost from this cause each year, or nearly exactly 1 per cent. This loss, estimated on

the basis of the pay and allowance of subordinate constables, would amount to between Rs. 3,800 to Rs. 4,000 per annum. But if we estimate it at 1 per cent. of the total cost of the police establishment, which has averaged about 8,50,000 rupees per annum during the last ten years, we should have to put it at more than double this.

This latter sum is probably nearer the mark as it allows for Hospital expenditure. In 1908 Police hospital expenditure exceeded Rs. 15,000, of which 25 per cent. may be put down at the proportionate cost of treating the cases of fever, which form over half the total admissions. Broadly speaking we may state therefore that fever causes a loss of about Rs. 7,500 :or £500 per annum to the police establishment of the City, of which loss more than one-half is due to 1 per cent. loss of duty among the subordinate police. As 75 per cent. of the fever cases treated are malarial in nature, 75 per cent. of this loss or Rs. 5,625 (£375) may be put down to malaria.

Applying this data to the general population, we may estimate as follows. The Census of 1906 showed 588,544 actual workers in the City. If we take their average earnings at Rs. 20 per month they amount to a total of Rs. 14,12,50,560 per annum; and if we estimate that 1 per cent. of this was lost either by the worker in wages or by the employer in work paid for but not done because of "fever" we get a sum of over 14,00,000 rupees. Of this sum 75 per cent. or Rs. 10,50,000 may be assumed to be lost on account of malaria.

This estimate takes no account of the 389,000 dependants in the City supported by the actual workers, sickness among whom causes considerable loss to the latter. For this it would be necessary to add several lakhs of rupees, so that it will be evident that an estimate of Rs. 12,00,000 or 13,00,000 as the cost of malaria to the City is a very low one, and probably much under the real amount.

137. The figure given above does not include loss of rent to landlords caused by the abandonment of houses in malarious localities and the loss to tenants who are forced to leave and perhaps pay two rents for a time; it makes no allowance for loss to private persons forced to go to considerable expenses for medical attendance or perhaps compelled to resign their appointments and leave the City in order to recover their health; and it does not include the loss occasioned by the disorganization and lessened efficiency of a business staff, a considerable proportion of whom are from time to time disabled by sickness.

If these and other losses, occasioned to the citizens of Bombay by malaria, could be totalled up, in all probability it would be found that the sum of Rs. 1/4 to Rs. 1/8 per head of the population, which has been taken as the estimate, represents only one-half or one-third of the amount paid away without return each year by the citizens of Bombay because of the existence of an easily preventable disease in their city.

CHAPTER V.

THE MOSQUITOES OF BOMBAY.

Section 1.

138. Bombay appears to have suffered from a plague of mosquitoes for many years. Aungier, nearly 250 years ago, writes of "The vermin created in the wells and tanks," and Ovington mentions "The prodigious growth of vermin and the venomous creatures in the monsoon," and it is more than probable that these remarks referred in part at least to mosquitoes. Lady West, in her diary written between 1825-1828, repeatedly complains of being tormented with mosquitoes, which appear to have been numerous in the Fort in her day; and Douglas, in his "Glimpses of Old Bombay," quotes some verses by a Bombay writer in 1829 which begin—

"Adieu Bombay! May I forget thee ever, pestiferous hole
all other pests excelling,
In dust, *mosquitoes*, pariah dogs, and liver; not
Milton's limbo would be worse to dwell in."

139. Shortly after the announcement of Ross' discovery, the late Colonel Weir, I. M. S., then Executive Health Officer of Bombay, turned his attention to the question of mosquitoes breeding in the City and referred to the matter in certain of his reports; and in 1899 Mr. Santo Crimp suggested that malaria-carrying mosquitoes might breed in the tanks in the City. But the late Mr. E. H. Aitken appears to have been the first to really investigate the mosquito fauna of Bombay. In an interesting letter on the subject, published in the Journal of the Bombay Natural History Society in 1900, Mr. Aitken refers to a number of mosquito-breeding places in different parts of the City in which plenty of Anopheles larvæ were found. He also mentions experiments with small fish as agents for destroying mosquito larvæ. In these experiments Mr. Aitken used a species of Haplochilus locally known as "Piku" but named by him "Scooties" because of their darting movements.

Among other observations, recorded by Mr. Aitken, one relating to the relative frequency with which adult Anopheles and Culex mosquitoes were to be met with in the Fort is of considerable interest.

He states:—

"As regards the nature of adult anopheles, the most remarkable fact "mentioned in my notes is that I have not seen one during the twelve "months excepting those that I reared. This fact will give the best idea "of what an insidious enemy we have to deal with. I lived most of the "years at the Bombay Club, within a stone-throw of the Frere Fountain, "in which anopheles were being produced by the thousand, but I never "saw one, though I was often tormented by culex, the larvæ of which "were comparatively scarce.

"All the mosquitoes that I have reared appear to belong to one "species, which is probably A. rossi."

140. During 1901 considerable attention was paid to mosquitoes in Bombay; and the Executive Health Officer in one of his reports makes the follwing statement:—

"The chief specimens of anopheles mosquitoes found in Bombay "are Anopheles Rossei, Barbarosei, Jamesei, Culicifacias, Stephensei and "Listonii. Of these the Anopheles Culicifacias and Listonii are the "only malaria-bearing mosquitoes known here at present."

This list of anopheles corresponds very closely with the findings during the present enquiry.

141. The Culicid fauna of Bombay is extensive; the number of different species both of Culicine and Anopheline mosquitoes is considerable and certain

of them, notably *Culex fatigans* and *Nysso-myzomyia rossi*, are met with in every part of the Island and are present in many localities in such countless numbers as to become a grave nuisance. In the dry season from October to June *Culex fatigans* is by far the commonest mosquito, but after the onset of the rains *Nysso-myzomyia rossi* is produced in enormous numbers, and in August and September, *Stegomyiæ*, notably *Stegomyia sugens*, *Stegomyia scutellaris* and *Stegomyia calopus* (*fasciata*) become unpleasantly numerous.

142. Among the different species of mosquitoes present in the Island the following have been noticed :—

Culicines—

Culex fatigans.
„ *tæneorrhynchus.*
„ *concolor.*
„ *tigripes.*
Stegomyia calopus or fasciata.
„ *scutellaris.*
„ *sugens.*
„ *gubernatorius* (Giles).
Desvoidea obturbans.
Mansonia uniformis (Giles).

There are also several other culicine species present, that have not been identified.

Anophelines—

Nysso-myzomyia rossi.
Neocellia stephensi.
Myzorhynchus barbirostris.
Nyssorhynchus jamesi.
„ *fuliginosus.*
Myzomyia listoni.
„ *culicifacies.*

143. According to the modern classification the Anopheline fauna of the Island may be divided into five groups or genera.

(1)	*Nysso-myzomyia*	represented by one species		*N. Rossi.*
(2)	*Neocellia*	„	„ „ „	*N. Stephensi.*
(3)	*Myzorhynchus*	„	„ „ „	*M. Barbirostris.*
(4)	*Nyssorhynchus*	„	„ two „	*N. Jamesi.* *N. Fuliginosus.*
(5)	*Myzomyia*	„	„ two „	*M. Listoni.* *M. Culicifacies.*

James and Liston in the 1st edition of their monograph on the Indian Anophelines also mention *Nysso-myzomyia punctulata*, *Pyretophorus jeyporiensis and Nyssorhynchus theobaldi* as having been found in Bombay ; but these species have not been met with during the course of the present enquiry.

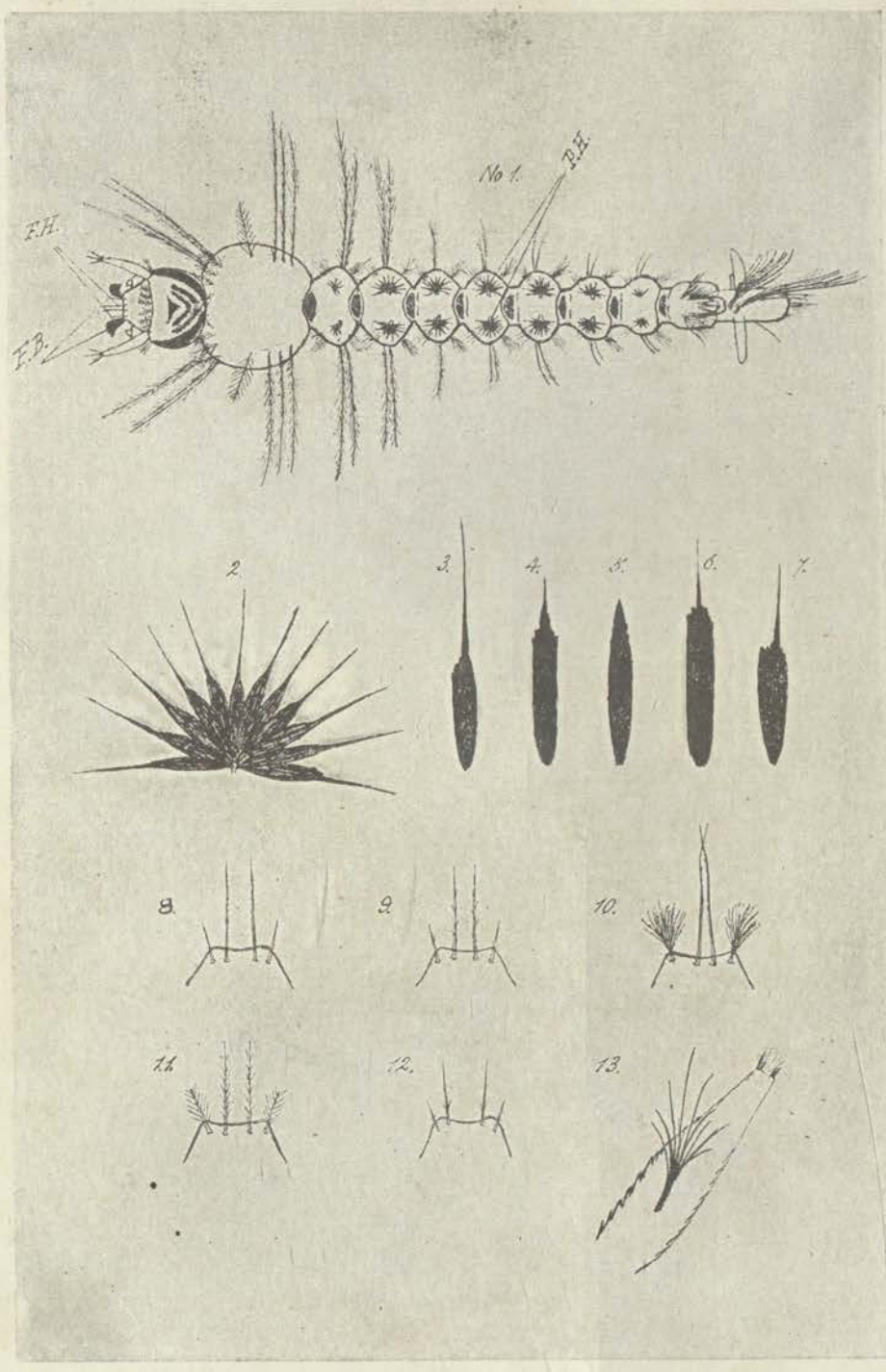
144. The general character of the above groups and a description of the different species present in Bombay is given below :—

Nysso-Myzomyia.

Generic characters.

Abdomen.—Dorsal and ventral surfaces of the last one or two segments carry scales as in the genus *Nyssorhynchus.*

Thorax.—With long narrow sharp-pointed scales as in the genus *Myzomyia* and with some broader short scales.



Key to Larvæ of Bombay Anopheles Mosquitoes.

(1) Diagram of Anopheles larva showing frontal hairs *F. H.*, which must not be confused with feeding brushes *F. B*, also palmate hairs or fans *P. H.*, a pair of which is usually present on most of the abdominal segments.

(2) Complete palmate hair or fan from larva of *N.-M. rossi.*

(3) Single leaflet from palmate hair or fan of *N.-M. rossi.*

(4) ,, ,, ,, ,, ,, ,, ,, ,, *N. stephensi.*

(5) ,, ,, ,, ,, ,, ,, ,, ,, *M. barbirostris.*

(6) ,, ,, ,, ,, ,, ,, ,, ,, *N. jamesi* and *N. fuliginosus.*

(7) ,, ,, ,, ,, ,, ,, ,, ,, *M. listoni* and *M. culicifacies.*

Note.—Palmate hairs are present on the thorax of both *M. listoni* and *M. culicifacies.*

(8) Frontal or clypeal hairs of larva of *N.-M. rossi.*

(9) ,, ,, ,, ,, ,, ,, ,, *N. stephensi.*

(10) ,, ,, ,, ,, ,, ,, ,, *M. barbirostris.*

(11) ,, ,, ,, ,, ,, ,, ,, *N. jamesi* and *N. fuliginosus.*

(12) ,, ,, ,, ,, ,, ,, ,, *M. listoni* and *M. culicifacies.*

(13) Special branched hair on inner side of antennæ of *M. barbirostris.*

Note.—The branching of the frontal hairs of *N. stephensi* and *M. listoni* is so fine that it requires a $\frac{1}{8}$th in. or higher power objective to see it.

This plate was originally prepared to illustrate a paper on the Natu al History of Bombay Malaria, which appeared in the Journal of the Bombay Natural History Society. It has been reproduced by permission.

Protheracic lobes.—With a tuft of scales.

Upright forked cephalic scales.—Of the usual broadly expending type.

Wing scales.—Not characteristic.

Nysso-Myzomyia Rossi.

Adult characters.—A fair sized mosquito, of a general light brown colour. The head is blackish, but possesses a well-developed frontal tuft of white hairs projecting forwards. The palpi have three white bands, and in the female, the outermost which includes the tips of the palpi is broad, the other two being narrow. The proboscis is dark brown with a yellowish tip. The wings are spotted with black especially along the border of the costa and the central spot resembles in shape an expanded "T". The legs are brownish in colour, but show white bandings at the joints, especially noticeable on the forelegs. There is no speckling of the legs.

Examination with a microscope shows many golden hairs and scattered narrow whitish scales on the thorax, dense yellowish brown hairs on the general surface of the abdomen and a few true scales on the last one or two segments; these scales are especially noticeable around the base of the claspers in the male.

Larval characters.—The frontal hairs on the clypeus of the larvæ are simple and unbranched. Palmate hairs are present from the second to the seventh abdominal segment. The terminal filament of each leaflet of the palmate hairs is very long, often longer than the basal portion. There is little or no marking or pigmentation on the shoulder of the leaflets at the origin of the terminal filaments.

Ovum.—Boat-shaped, with a broad upper surface. There is a well-developed fringe striated throughout its whole length, and scallop-shell shaped floats which touch the margin of the anterior surface. The lower surface is not ornamented.

145. Neocellia.

Generic characters.

Abdomen.—The dorsal surface of every segment carries scales. The ventral surface of the last three or four segments carry scales. None of the scales are aggregated to form tufts.

Thorax.—With a short, broad true scales.

Protheracic lobes.—With a tuft of scales.

Upright forked cephalic scales.—Of the usual broadly expending type.

Wing scales.—Not characteristic.

Neocellia Stephensi.

Adult characters.—A medium sized mosquito closely resembling *Nysso-myzomyia rossi* in general appearance. Head blackish, with a prominent frontal tuft of white hairs projecting forwards. The palpi have three white bands which in the male are almost indistinguishable from those of *Nysso-myzimyia rossi*. In the female the medium white band is broad and only separated from the broad terminal white band by a narrow band of black; the proximal white band is narrow; and there are also a few scattered white scales among the black scales of the palpi, which give it a somewhat speckled appearance. The proboscis is blackish brown in colour with a whitish tip. The wings are spotted with black especially along the costa and there is a central "T"-shaped spot with a small black spot like a *full-stop* adjoining it. The legs are thickly speckled with white scales and there are narrow white bands at certain of the joints.

Examination under a microscope shows the thorax to be thickly covered with broad white scales and dark hairs; the ventral surface of the last two or three segments are also covered with scales, but there are no scale tufts.

Larval characters.—The frontal hairs of the clypeus of the larva are very slightly branched, the branching being sometimes so fine as to require a one-sixth objective or higher power to define it. The palmate hairs are present on the first to the seventh abdominal segments; the leaflets are usually pigmented and broken-looking at the shoulder and the terminal filament is comparatively short.

Ovum.—The ova are boat-shaped, but the upper surface is considerably contracted owing to the striated scallop-shell shaped floats which almost meet in the centre.

146. MYZORHYNCHUS.

Generic characters.

Abdomen.—The dorsal surface with hairs only. The ventral surface with a tuft of scales projecting vertically downwards from the apex of the seventh segment in the mid line.

Thoras.—With sharp pointed very narrow, curved scales as in the genus Myzomyia.

Prothoracic lobes.—With a dense tuft of broad scales.

Upright forked cephalic scales.—Very broadly expending.

Wing scales.—Not characteristic.

MYZORHYNCHUS BARBIROSTRIS.

Adult characters.—This is a very large mosquito, easily recognized by its deep blackish colour and thick unbanded palpi. Beyond a frontal tuft of whitish hairs, and a few white scales on the occiput and on the wings the entire mosquito is a deep brown or black colour. The legs are dark brown with lighter patches at the joints.

On examination with a miscroscope the head is seen to be covered with black broadly expanding upright forked scales; the thorax is covered with very narrow curved hair-like brown or blackish scales; and the abdomen has many black hairs on its dorsal surface and possesses a tuft of black scales on its ventral surface projecting downwards from the apex of the seventh segment in the mid line. The scales forming the wing-fringe are mostly black, but there is a light area at the apex of the wings and another somewhat below at the apex of the posterior branch of the fifth longitudinal vein.

Larval characters.—The larva are usually black or brown in colour, but generally show two whitish bands on the upper surface of the abdomen. The abdominal segments do not taper so rapidly as in the larva of many other species and in young larvæ the absence of tapering is so marked, as to give them almost the appearance of equal width from thorax to tail. The frontal hairs are peculiar, the inner hairs being usually long, simple and unbranched and often crossed over one another at the tip. The external frontal hairs are thickly branched and resemble cockades. The antennae bear a large branched hair on their inner aspect.

Ovum.—The upper surface is very narrow, the floats do not touch the margin of the upper surface. The lower surface is ornamented with polygonal markings. Viewed laterally the pointed extremities of the upper surface are seen to be turned up.

147. NYSSORHYNCHUS.

Generic characters.

Abdomen.—The dorsal and ventral surfaces of the last three or two segments carry scales which are not aggregated to form tufts.

Thorax.—With short, broad true scales.

Protheracic lobes.—Without a tuft of scales.

Upright forked cephalic scales.—Of the usual broadly expending type.

Wing scales.—Not characteristic.

Nyssorhynchus Jamesi.

Adult characters.—This is rather a small mosquito. Usually it is rather blackish in colour, but it may sometimes be found of a lighter grey or brown appearance. It has a pecular habit when at rest of waving its white tipped hind legs about in the air. It possesses three rather narrow white bands on its palpi, the terminal one being the widest. The dorsal aspect of the thorax is grey owing to the presence of white scales, the lateral and ventral aspects are dark. The abdomen is dark in colour. The wings are spotted with black and white and the legs are thickly speckled with white except the last three segments of the hind tarsi which are snowwhite. Examination with a microscope shows numerous short broad white scales and dark hairs on the thorax, and dark scales on the last two or three segments of the abdomen. The rest of the abdomen is covered with brown hairs. The characteristic markings are the speckling of the legs and the white hind tarsi.

Larval characters.—The larvæ are usually of a reddish brown colour and present rather a hairy appearance. The frontal hairs possess numerous lateral branches. The palmate hairs are large and are present on the second to the seventh abdominal segments; the terminal filament is rather short.

Ovum.—The upper surface is rather narrow. The floats are rather short and oval and are placed far forwards, the fringe is fairly developed but it is not continued over the floats.

148. *Nyssorhynchus Fuliginosus.*

This mosquito, which has only once been found in Bombay, resembles *Nyssorhynchus jamesi* very closely, the only marked difference being in the fact that its legs are not speckled with white as are those of *Nyssorhynchus jamesi.* In every other particular it is the same; and the larvae and ova also are almost identical with those of *Nyssorhynchus jamesi.*

149. Myzomyia.

Generic characters.

Abdomen.—Only the last segment carries scales.

Thorax.—With hairs and sharp-pointed curve scales.

Prothoracic lobes.—With a conspicuous tuft of true scales.

Upright forked cephalic scales.—Of the usual type but forming tufts at the postero-lateral angles.

Wing scales.—Not characteristic.

Myzomyia Listoni.

Adult characters.—This is an exceedingly small mosquito of very fragile appearance, with very delicate slender legs. It is usually of a dark grey or blackish colour with wings spotted with white. The palpi have three almost equal white bands, the outermost extending to the tip. The proboscis is black with a yellowish tip. The head is covered with dark brown and white upright scales and there is a frontal tuft of hairs. The thorax is covered with white scales on a dark ground. The abdomen is of a dark black colour with many yellowish hairs. The wing costa is marked by four white areas, the smallest near the apex.

It is generally stated that a characteristic feature of the wing markings of Myzomyia listoni is the white scaled 3rd longitudinal vein; but in the variety present in Bombay this vein is black scaled, like that of *M. culicifacies.* The legs are generally dark, almost black in colour, but occasionally slightly paler areas are present near the joints. Major S. P. James, I.M.S., has mentioned as characteristic features distinguishing *M. listoni* from *M. culicifacies* the fact that the 1st fork cell of the wing is more than $1\frac{1}{2}$ times the length of the 2nd fork cell, and that there are 5 pale areas on the wing fringe.

Characters of the larva.—The frontal hairs of the larvæ found in Bombay possess a few fine lateral branches similar to those seen on the larvæ of *N. stephensi.* Palmate hairs are present on the thorax as well as on the abdominal segments; they are generally large and prominent; the leaflets are provided with a well marked shoulder which is usually serrated and pigmented at the origin of the terminal filament. The terminal filament is short.

Ovum.—Upper surface very narrow; floats do not touch margin of upper surface; lower surface not ornamented.

Myzomyia Culicifacies.

150. There is no necessity to enter into a detailed description of this mosquito which resembles *M. listoni* very closely. The specimens met with in Bombay have been usually slightly larger and rather paler in colour than *M. listoni* and possess a marked culicine attitude when at rest.

Major S. P. James mentions as a characteristic distinction between this mosquito and *M. listoni*, the fact that the 1st fork cell is less than $1\frac{1}{2}$ times the length of the 2nd fork cell, and the wing fringe has 2 white areas instead of 5.

Larvæ and Ova.—The larvæ and ova are indistinguishable from those of *M. listoni.*

Section 2.

151. INFECTION OF MOSQUITOES.—In discussing the mosquitoes of Bombay in relation to the spread of malaria the vast bulk of the insects that exist in the City may be at once passed over. Neither the ubiquitous *Culex fatigans* nor the annoying *Stegomyia* are dangerous from the point of view of malaria, and other mosquitoes which belong to the Culicine family are non-carriers of the disease likewise.

152. Among mosquitoes of the Anopheline family (to which the carriers of malaria alone belong) there are, as has already been pointed out, 7 species present in Bombay. By far the most common species is *Nysso-myzomyia rossi.* It abounds everywhere and is often to be found in extraordinary numbers; and it is a matter of some importance to learn whether or not it is concerned in the transmission of malaria in Bombay.

153. A large amount of evidence has been collected from time to time which appears to show that *N. rossi* is not concerned in the spread of malaria in India. In 1901 Stephens and Christophers, the members of the Royal Society's Commission on Malaria, examined very large numbers of *N. rossi* caught in dwelling-houses in Calcutta, Mian Mir, Ennur and the Bengal Duars without finding a single infected insect. They record the dissection of 1,139 specimens, 860 of which were caught at Mian Mir and Ennur, at the same time and in the same places as smaller numbers of *M. culicifacies.* In both stations malarial parasites were uniformly absent from *rossi* whereas in specimens of *M. culifacies,* sporozoits of malaria were present to the extent of 4·6 per cent. and 8·6 per cent., respectively.

154. But although these observations of Stephens and Christophers are almost conclusive, it was felt that it would be wise to make absolutely sure that *rossi* did not behave in a different manner under conditions present in Bombay, and this point was investigated early in the course of the enquiry. In 1908 Major W. Glen Liston, I. M. S., caught a number of adult mosquitoes in dwelling-houses while investigating malaria near the New Docks in the Frere Road. Among those mosquitoes two species of anopheles were present, *Nysso-myzomyia rossi* and *N. stephensi ;* and examination of a number of the latter resulted in the important discovery that they were infected with malarial parasites in as high a proportion as 25 per cent. In view of this fact the same locality was chosen as a suitable place from which to obtain mosquitoes for systematic examination, and during the investigation adult mosquitoes were caught there at frequent intervals. With few exceptions these mosquitoes when caught were found to be full of blood, presumably derived from the inmates of the houses in which they were found. Among these inmates were many children who showed a spleen index of 70 to 80 per cent. and a parasite

index of about 40 per cent. As it was considered advisable to examine both the stomach and salivary glands of the mosquitoes, in order to determine the presence or absence of both the zygote and sporozoit stage of the malaria parasite, it was necessary to keep them for a time until their stomachs became empty.

155. A total of 4,235 dissections of mosquitoes were carried out during the investigation, about 2,050 of which were for the purpose of examining the salivary glands and the remainder for the examination of the stomach or midgut. Of the mosquitoes examined the great majority were specimens of *Nysso-myzomyia rossi* and *N. stephensi.*

The examination of 925 stomachs and 806 salivary glands of *Nysso-myzomyia rossi* gave entirely negative results; whereas the examination of adult *Neocellia stephensi* showed among 1,228 stomachs, 91 or 7·4 per cent. infected with zygotes of malaria, and of 1,217 salivary glands 30 or 2·4 per cent. with sporozoits.

156. A few feeding experiments carried out with these two species of anopheles gave similar results. Of 51 *rossi* fed upon cases of malaria harbouring crescent infections none showed zygote development, whereas among 24 *stephensi* two developed zygotes in the midgut.

During the examination of mosquitoes at certain seasons of the year the infections met with among *N. stephensi* were very numerous. In July 1910, 10 per cent. harboured sporozoits and in August, 18 per cent. were found to contain zygotes; but among large numbers of *rossi* caught in the same houses at the same time, none showed a sign of infection.

These observations are most important as they appear to prove conclusively that *Nysso-myzomyia rossi* is not concerned in the spread of malaria in Bombay.

157. The only mosquitoes that were found infected with malaria during the investigation belonged to the species *N. stephensi.* It may be remarked that laboratory experiments conducted by Stephens and Christophers with *N. stephensi* as long ago as 1901 showed that malarial parasites could complete their development in the stomach and pass to the salivary glands of this mosquito. This observation was not confirmed by the finding of naturally infected insects until 1903 when Major Liston, I. M. S., investigated the question in Bombay. But although the dangerous nature of *N. stephensi* was not definitely proved until 1908 there is not the least doubt that it had been spreading malaria for many years in Bombay City, and it is a mistake to suppose it has only recently become a carrier of malaria.

158. In addition to *N. stephensi* three other species among the anopheles mosquitoes of Bombay have been shown to be definitely concerned in the spread of malaria in certain parts of India.

They are—

(1) *M. culicifacies.*

(2) *M. listoni.*

(3) *N. fuliginosus.*

Investigation has not as yet shown the two remaining Bombay anopheles to be natural carriers of infection, and although both *N. jamesi* and *M. barbirostris* have been infected experimentally in the laboratory there are strong reasons for supposing that the latter at all events is generally innocous. As it was impossible to catch any great number of adult *N. jamesi, M. barbirostris, M. culicifacies* and *M. listoni* during the investigation, only a very few could be dissected, and the negative results obtained are inconclusive, but there is strong presumptive evidence that *M. barbirostris* is not a common carrier of malaria in Bombay, because the parts of the island where it is most numerous are almost free of malarial infection.

159. The observations upon *N. stephensi* which have been carried out regularly since July 1909 bring to light certain interesting facts regarding the seasonal prevalence of malarial infection among mosquitoes. This is of some importance as there is a direct relation between the existence of malaria-infected mosquitoes and the occurrence of fresh infections in man.

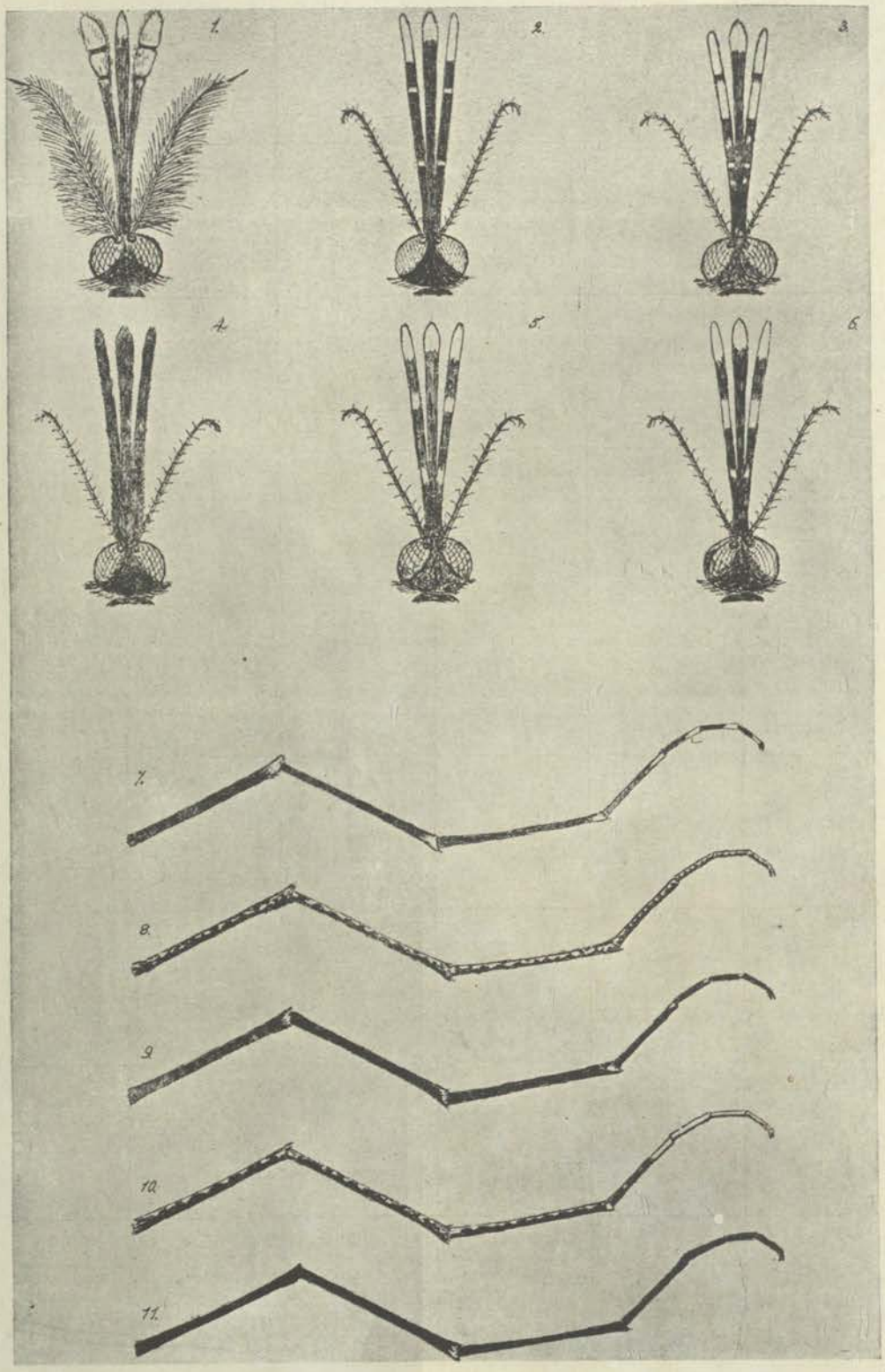
The following table gives the results of the systematic examination of 1,228 stomachs of *N. stephensi* :—

Examination of Midgut for Zygotes.

Month.	Number dissected.	Number infected.	Percentage infected.	Total zygotes seen.
1909.				
July ...	69	11	15·2	36
August ..	103	12	11·7	56
September ..	32	3	9·3	7
October ...	27	3	11·1	10
November ..	18	...	...	...
December ..	10	...	...	...
1910.				
January ..	12	...	...	...
February ...	10	...	...	...
March ..	...	...	...	...
April ..	12	...	...	...
May ..	59	...	...	...
June ..	25	...	...	...
July ..	105	12	11·4	108
August ..	75	14	18·6	158
September ..	71	10	14·0	52
October ..	82	9	10·9	35
November ..	60	5	8·3	6
December ..	67	5	7·4	29
1911.				
January ..	153	6	3·9	15
February ..	173	1	0·5	2
March ..	65	...	...	...
Total ...	1,228	91	7·4	...

The result of the examination of 1,217 salivary glands of *Neocellia stephensi* is given below :—

Month.	Number dissected.	Number infected.	Percentage infected.
1909.			
July	63	1	1·5
August ...	70	4	5·7
September ...	56	2	3·5
October ...	14	1	7·1
November ...	18	...	...
December ...	11	...	...
1910.			
January ..	6	...	...
February ...	...	...	...
March ...	...	...	...
April ...	11	...	...
May ...	14	...	...
June ...	15	...	...
July ...	90	9	10 0
August ...	158	5	3·1
September ...	79	4	5·0
October ...	94	2	2·1
November ...	60	1	1·6
December ...	67	...	...
1911.			
January ...	153	1	0·6
February ...	173	...	...
March ...	65	...	...
Total ...	1,217	30	2·4



Key to Bombay Anopheles Mosquitoes.

No. 1. Head of Male Anopheles showing proboscis, spatulate palpi and plumose antennæ. The banding of the palpi in the male anopheles is not characteristic and affords no help to recognition of the species.

Nos. 2-6. Heads and Appendages of Female Anopheles showing characteristic banding of palpi.

No. 2. *N.-M. rossi.*

No. 3. *N. stephensi.*

No. 4 *M. barbirostris.*

No. 5. *N. jamesi, and N. fuliginosus.*

No. 6. *M. culicifacies, and M. listoni.*

No. 7. Hind leg of *M. rossi* showing white bands at the joints.

No. 8. ,, ,, ,, *N. stephensi* showing speckling.

No. 9. ,, ,, ,, *M. barbirostris* unbanded almost completely black.

No 10. ,, ,, ,, *N. jamesi* showing the white tips and the speckling. The legs of *N. fuliginosus* are unspeckled but are white tipped.

No. 11. ,, ,, ,, *M. listoni and M. culicifacies* unbanded black or dark brown.

This plate was originally prepared to illustrate a paper on the Natural History of Bombay Malaria, which appeared in the Journal of the Bombay Natural History Society. It is reproduced by permission.

Infected anopheles were not met with before the middle of July either in 1909 or 1910; in the dry weather of 1909-1910 156 stomachs and 83 salivary glands of *N. stephensi* examined consecutively gave negative results; in February and March 1911, 238 stomachs showed only one infection; and the same number of salivary glands were examined without the finding of sporozoits.

160. The relation of Anopheline infection to weather was noted in 1910. In July of that year a sudden break occurred in the rains, only 1·79 inches of rain falling during a period of three weeks, and there being only three days during this period on which the rainfall was 0·25 inches or more. The weather during this period was bright and sunny, the temperature rose slightly and the atmospheric humidity remained very high. At this time a large number of *N. stephensi* became infected with malaria and the infections reached maturity very rapidly as shown by the fact that 11·4 per cent. of those examined showed zygotes in their stomachs and 10 per cent. had sporozoits in their salivary glands. A little later, during the first half of August, the occurrence of a period of almost unbroken rain appeared to reduce the proportion of sporozoit-carrying anopheles considerably and though 18·6 per cent. of those examined had zygotes in their midgut only 5 out of 158 or 3·1 per cent. showed sporozoits in their salivary glands.

Section 3.

161. MOSQUITO LARVÆ.—Since the commencement of the enquiry about 20,000 collections of water of all kinds in different parts of the island, have been examined for mosquito larvæ, including about 5,000 wells, nearly 5,000 cisterns, 2,386 small masonry tanks in gardens and compounds and 215 large tanks, 551 public and private fountains, 3,500 tubs, barrels and buckets, many hundreds of large and small pools and many minor collections of water in tubs, troughs, tin-pots and hollows in old machinery, etc. In a large proportion of these potential breeding places larvæ of different species of *Culex* have been met with and *N.-M. rossi* has been found breeding in very many of them.

162. *Method of examining breeding places for Mosquito Larvæ.*—Early in the enquiry it became apparent that many of the collections of water used as breeding place by the mosquitoes of Bombay were of such a nature that it was not possible to examine them properly by means of ordinary dippers. In Bombay wells form common breeding place of anopheles mosquitoes and in the vast majority of cases the surface of the water can only be reached with difficulty; and although it is sometimes possible to dip larvæ out of a well by means of a bucket and rope, this is by no means a certain method of examination. On some occasions as many as twenty buckets of water have been removed from a well known to contain larvæ without one being found in this way.

163. To meet the difficulty of examining wells a special form of apparatus was devised early in the course of the investigation, a brief description of which is as follows. A loop about 15 to 18 inches in diameter is made of very thick brass or galvanized iron wire, and upon this frame a shallow net of very thin mull-mull or muslin is stretched. The net is suspended by three short brass chains about 2 feet long, which are attached to the frame below and to a small ring above. To the ring a rope is tied and the net can then be lowered to any required depth. When a well has to be examined the net is lowered to about a foot beneath the surface of the water, the weight of the frame causing it to sink. It is then gently moved below the surface and pulled up at a point some distance from where it first entered the water. On examining the net larvæ, if plentiful, are easily seen and can be secured by washing them off into bowl of clean water. If larvæ are very small or scanty in number they are not easily seen on mere inspection of the net but by inverting it into a shallow white enamelled vessel of water they can be washed off and easily detected. It has been found useful to adopt this washing of the inverted net as a routine method, and it has been found that a large-sized white enamelled frying pan is a useful vessel in which to invert the net and wash its surface. The value of the net method for examining wells is shown by the fact that in certain areas double the number were found to be infested with larvæ of *Neocellia stephensi*, than had been supposed, when examination had been made by means of a bucket.

164. For examining cisterns and tanks mull-mull nets on longer or shorter handles were found effective. A net of this kind can be introduced into a cistern and swept rapidly over the whole surface of the water and on removal quickly inverted and washed in a white enamelled vessel of water. Larvæ if present are easily detected in this way. By the use of a net the presence of larvæ of *Neocellia stephensi* was demonstrated in several hundreds of cisterns which had previously been examined by means of dippers and declared to be quite free of mosquito larvæ; and it was found possible to show the presence of larvæ in the Malabár Hill reservoir where the water is 18 feet deep and absolutely clear, when previous examination by dippers had given uniformly negative results.

Anopheline Larvæ.

165. During the investigation larvæ of *N. stephensi* were met with in 1,693 different collections of water; larvæ of *M. barbirostris* in about 500 places; larvæ of *N. jamesi* in nearly 100 and larvæ of *M. culicifacies* and *M. listoni* in about 50. All these species of anopheles with the exception of *N. rossi* have been found breeding most frequently in open wells.

166. The number of breeding places of *Neocellia stephensi* found in each ward has been as follows:—

A.	Ward	688	41·1 per cent.	of total.
B.	„	108	6·3 „	„
C.	„	472	27·8 „	„
D.	„	305	18·0 „	„
E.	„	120	7·8 „	„
F.	„	*Nil.*		
G.	„	*Nil.*		

167. The nature of the breeding places chosen by *Neocellia stephensi* is shown below. Among a total of nearly 1,700 collections of water harbouring the larvæ of this mosquito the various breeding places were approximately as follows:—

Open wells	65	per cent.
Open and improperly closed cisterns ...	10	„
Fountains	2	„
Masonry and other tanks	4	„
Tubs, barrels, tin-pots and minor collections of water	9	„
Pools of water	10	„

168. These breeding places may be divided into two classes:—

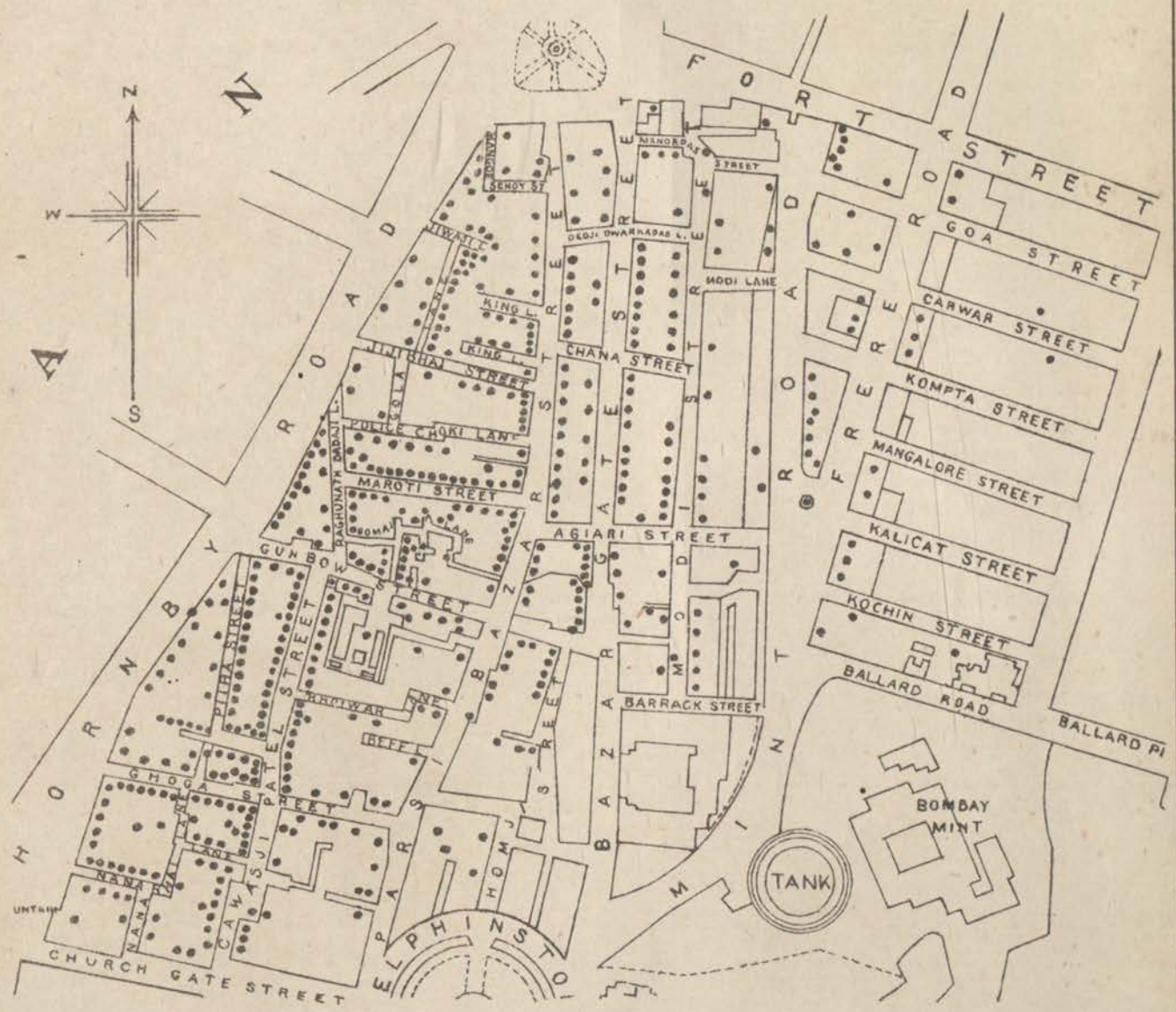
(1) Permanent breeding places.

(2) Temporary breeding places.

The permanent breeding places which chiefly consist of open wells, open and improperly closed cisterns, fountains and garden and other tanks, are of the utmost importance as they enable the mosquito to continue breeding unchecked throughout the year and provide the source from which temporary breeding places become infected from time to time. Besides the ordinary permanent breeding places there are a few special ones in certain localities. The filter-beds and reservoirs at Malabár and Bhandarwada Hills are prolific breeding grounds and the waste water and leakage from these water works also form small streamlets and pools in which the mosquito can breed all the year round. Certain places on the foreshore in Colaba and Walkeshwar, where pools of brackish water remain throughout the year, also form permanent breeding places from which temporary pools created during the monsoon subsequently become infected.

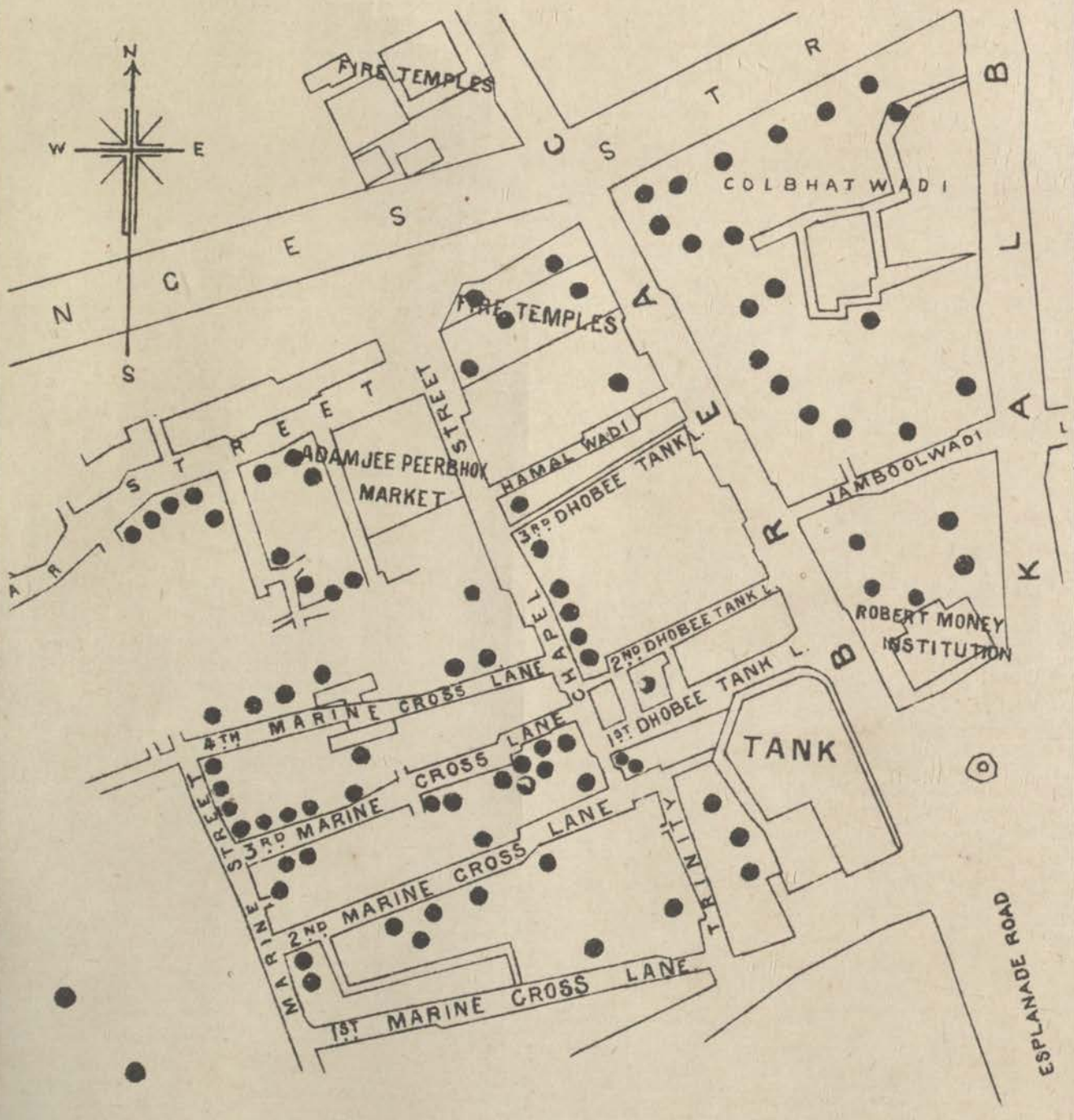
169. Temporary breeding places are usually only formed during the rainy season and speedily disappear after the commencement of the dry weather. They consist chiefly in surface pools of water which are formed after heavy rains on the uneven surface of the ground in large compounds such as that of the New Dock Works enclosure, the Railway Yards and many other places, earas

MAP
OF
NORTH FORT [133 ACRES]
SHOWING DISTRIBUTION OF WELLS
50 % of the wells harbour N. stephensi



Gov^t Photozinco Office Poona 1911.

MAP
OF
PORTION OF DHOBI TALAO
[ABOUT 25 ACRES]
SHOWING WELLS
80 % of the wells are infested with N. stephensi.



Govt. Photozinco. Office, Poona, 1911

in which building s have been demolished, sites upon which building operations are going on and many parts of the foreshore. A number of minor temporary breeding places also occur in the rainy season in the form of tubs, buckets, tin-pots and in hollows in iron machinery and masonry. In areas containing many permanent breeding places of *Neocellia stephensi*, garden tubs and barrels of water in stables may often be found harbouring larvæ, if the water has been allowed to remain unchanged for a time.

170. More than half the wells in A. Ward; one-third of those in C. and D. Wards and 10 per cent. of those in B. and E. Wards are infected with *Neocellia stephensi*. Many of the wells in A., B, and parts of C. Wards contained a great number of larvæ, but in the wells situated in D. and E. Wards and the north of C. Ward larvæ were usually met with in comparatively scanty numbers. The largest number of infected wells was met with in A. and C. Wards. Many of the wells in these wards are inside the houses, either in the basement or situated under the central shaft which often passes up through the house and usually contains the stairways and landings on each floor. All these house wells are so arranged that tenants of the upper floors can draw water, without descending to the mouth of the well, by letting down a vessel with a rope. It has been found that wells of this character generally harbour a far greater number of larvæ of *N. stephensi* than open wells in gardens and compounds; and even when they appeared clean and free from floating matter and were in constant use numerous larvæ were often present. Many of the wells in D. and the northern portion of C. Ward are of a different character. They are not house wells but are situated in yards or gardens and owing possibly to the fact that the wells in the open usually contain a very large amount of aquatic insect life, among which there are many natural enemies of mosquito larvæ, such larvæ when present were often found in very scanty numbers.

171. *Neocellia stephensi* is essentially a domestic mosquito. It lives and breeds in the immediate neighbourhood of human dwellings and adapts itself to all sorts of artificial conditions. In particular its use of artificial collections of water for breeding purposes shows it to possess very different habits to the species of anopheles usually associated with the dissemination of malaria, and serves to mark it out as especially suited for existence in towns. It exercises extraordinary ingenuity in its choice of breeding places, its larvæ being found in wells 20 to 30 feet or more in depth and in cisterns on the roofs of houses as much as 70 to 100 feet above the ground. It is often found in dark wells in the basement of houses and in cisterns in which the cover allows only the narrowest of openings by which the gravid female may enter and the newly hatched swarm pass out.

172. The larvæ are extraordinarily sensitive to danger. The falling of a shadow upon them or the slightest disturbance of the water in which are they breeding will cause them to sink rapidly to the bottom, where they remain quiescent for periods often as long as twenty minutes or more. They breed readily in deep water and they may often be found in water that is quite clear and free from weed. They have been discovered in the reservoir at Malabár Hill which has a depth of 18 feet; and many of the wells, iron cisterns and masonry tanks in which they most commonly breed usually have a depth of clear water of from 3 to 10 feet or more. In spite of statements to the contrary they are frequently to be met with in wells that are apparently clean and in daily use. They breed in salt water almost as readily as fresh. Gravid female *Neocellia stephensi* will deposit their eggs upon sea water and larvæ hatch out and live in this medium, but those that have been hatched in fresh water quickly die when transferred to salt water.

173. In the north of the island there are many wells but few or none of them are inside the houses. In F. and G. Wards among 1,600 wells not one was found to harbour larvæ of *Neocellia stephensi* though a few contained larvæ of *Myzomyia listoni* or *Myzomyia culicifacies*. These larvæ were at first mistaken for the larvæ of *Neocellia stephensi* which they resembled very closely. Like *N. stephensi*, *M. listoni* and *M. culicifacies* are carriers of malaria but fortunately they have only been met with in exceedingly scanty numbers. They were present in about 50 wells in the northern half of the island.

The absence of *N. stephensi* from the north of the island is probably due to the imperfect means of communication between this part and the Fort. Road communication between the north and south of Bombay has never been good and even at the present time although the facilities for vehicular traffic have been greatly improved there is very little direct communication by covered vehicles between the south of the City and the extreme north of the island.

174. The larvæ of *Mysorhynchus barbirostris* occurs most commonly in F., G. and E. Wards, but it has also been met with in the very centre of the City. *Myssorhynchus jamesi* is most often found in the west and north of the island and *Myzomyia listoni* and *Myzomiya culicifacies* in the east and north, round about Parel village. At one time *M. listoni* was fairly common in the vicinity of the reservoir at Malabár Hill and Mazagaon, and Major W. Glen Liston I. M. S., found it breeding in considerable numbers in streamlets caused by leaks from the water works. But lately it seems to have disappeared and at the present time *N. stephensi* and *N. Jamesi* may be met with in the few breeding places of this kind which still exist.

Culex Larvæ

175. It is unnecessary to enter into a detailed description of the Culicine mosquitoes of Bombay, but a few facts regarding the species most commonly met with in the City are recorded below.

Culex fatigans is the most common species of mosquito in many parts of Bombay. It is found in enormous numbers even in some of the most densely populated areas; and is usually most troublesome in the dry weather and shortly after the close of the monsoon. The entrances of the storm-water drains with their catch-pits form some of the most prolific breeding places for this mosquito; and during the dry season when a small quantity of water passes into these drains by reason of the watering of the streets and roads enormous numbers of larvæ may be found in a considerable proportion of these catch-pits. *C. fatigans* breeds most readily in foul water. Myriads of larvæ may often be found in stagnant pools of brackish water that occur on the foreshore in the area between the high and low tide line; and they are especially numerous in such places if fæcal contamination is common there. At Malabár Hill very large numbers used to breed in the septic tank of the sewage installation until measures were taken to prevent them; and in the septic tank at Mátunga Asylum they are still to be found in enormous numbers. They are also met with in large numbers of unused wells, of which there are a great number in the City, many of them being exceedingly foul, and they are almost invariably present in minor collections of water such as occur in barrels, tubs, tin-pots, disused garden tanks, especially if the water has remained standing for a few days.

In the large open storm-water channels larvæ of *C. fatigans* are always to be found in large numbers and they are commonly to be met with in the smaller and fouler collections of water that occur in uneven ground in every part of the City during and after the monsoon. Swarms of the adult mosquito, bred out from the storm-water drains, haunt many of the houses in the City; and when it is almost impossible to catch adult anopheles during the dry season, scores of adult *C. fatigans* may be found with ease. In almost every instance where complaints are made of the prevalence of mosquitoes, investigation shows the presence of large numbers of this species and owing to the unsufferable nuisance caused by them in many parts of the City there is a very prevalent notion among people who have heard the bare statement that "mosquitoes carry malaria," that drains, gutter-traps and storm-water catch-pits are largely responsible for the existence of malaria in Bombay.

176. *Stegomyia* mosquitoes do not become very prevalent in Bombay until about August or September, except in buildings well supplied with fire buckets, where they are common all the year round. In dwelling houses also where plants are kept growing in vessels of water, or where flower vases are not frequently attended to, *Stegomyia* may be met with at all times of the year. *Stegomyia* larvæ are not uncommon in the antiformicas or small vessels of water used to

prevent ants from gaining access to tables, food-safes, etc., and they have also not unfrequently been found in large numbers in wells, garden-tubs, stable-tubs, etc. During the monsoon when countless small collections of water occur in flower pots, broken bottles, tins and hollows in trees and many other places they become exceedingly numerous. The most common species are *Stegomia scutellaris, Stegomia fasciata* (the carrier of Yellow fever in the West Indies), and *Stegomyia sugens*, and these three species may be met with in all parts of the Island. They are specially common in A. Ward where there are numerous offices and buildings containing fire buckets filled with water and in D. Ward especially on Malabár Hill where many bungalows with large gardens exist.

177. *Culex concolor and Culex tigripes.*—These two species of Culex which resemble one another very closely, are very large mosquitoes; they are very common in many parts of Bombay; and they usually breed in collections of fairly clean water. Their larvæ are peculiar, because, unlike most culicine larvæ, they float nearly horizontal in the water, in a position somewhat resembling that adopted by anopheles larvæ. They attain a very large size and they are cannibal in character, greedily devouring other mosquito larvæ that may be sharing the same breeding-place with them and even feeding upon one another. Their prevalence and relative distribution may be shown by the fact that they were met with in 721 different breeding places during the present enquiry. These breeding places were distributed as follows :—

A. Ward	...	...	45
B. „	...	...	44
C. „	...	...	142
D. „	...	...	186
E. „	...	...	210
F. „	...	...	50
G. „	...	...	44

There is no evidence to show that *Culex concolor* and *Culex tigripes* are harmful to man; they do not appear to attack man very readily; and in view of the fact that they undoubtedly serve to reduce the numbers of other and possibly dangerous species of mosquitoes they must be looked upon as being rather beneficial than otherwise.

178. The larvæ of *Culex concolor* does not seek its prey, but waits for its approach. It usually assumes an almost horizontal position just below the surface of the water, admirably suited for attack upon larvæ of anopheles, which float on the surface. Occasionally it may be seen to turn its body in a half circle, when any moving object comes near it, as if it were keeping a sharp look-out for the approach of its prey. It is exceedingly voracious and when hungry will seize any larva that ventures with striking distance, the movements of its head and neck being so rapid that the eye cannot follow them. Small larvæ are swallowed whole, disappearing instantaneously, large larvæ are seized and held remorselessly in spite of their struggles, and rapidly devoured while still alive.

179. The following observation shows how destructive *C. concolor* may be to other mosquitoes. Four large larvæ of *Culex concolor*, when placed in a bowl containing a number of larvæ of *Neocellia stephensi* of different sizes, immediately began to seize and devour them; and in the course of two hours had destroyed over 50. It is interesting to note that breeding places which early in the season contained large numbers of larvæ of *Neocellia stephensi*, and which later in the year contained larvæ of *Culex concolor* also, were subsequently found to contain only the larvæ of *Culex concolor*. Unfortunately the habit of preying upon one another in default of other mosquito larvæ tends to limit their number, and though it is probable that they may effect some good in areas where they are plentiful by destroying the larvæ of *Neocellia stephensi*, there is no evidence to show to what extent this may take place.

180. *Desvoidia obturbans.*—*Desvoidia obturbans* (formerly called *Culex obturbans* or *Armigeres obturbans*) is another species of mosquito present in Bombay whose larvæ possess cannibal tendencies, but it is not so common as *Culex concolor*, and as it usually breeds in foul water it rarely preys upon

dangerous anopheles. The adult mosquito is very large and is coloured a dull black and white. Its larvæ resemble very large Stegomyia larvæ and assume the same position in water, hanging nearly perpendicular with the head downwards. They breed in very foul water and on one occasion many hundred were found in a vessel containing stale urine.

Several other species of mosquitoes, mostly Culicines, may be found in all parts of the island. Among those may be mentioned a species of *Mansonia*, probably *Mansonia uniformis*, which is present in certain localities. Towards the centre and north of the Island nearly every pool of water containing weed or alge is found to harbour numerous larvæ of *Culex tænorhynchus* often in association with enormous numbers of the larvæ of *N. rossi*.

Section 4.

181. THE NATURAL ENEMIES OF MOSQUITOES.—It has long been known that the number of mosquitoes may be largely reduced by the attacks of natural enemies. The adult insects often fall a prey to birds, bats and predacious insects and certain species of fish also attack and devour large numbers when they approach sufficiently near the surface of the water. Two species of fish, *Haplochilus lineatus* and *Anabas scandens*, occurring in streams, pools and tanks in the neighbourhood of Bombay, readily take flying mosquitoes in this way, leaping six inches or more out of the water for the purpose.

182. Ants will also attack and devour adult mosquitoes if they happen to be in an enclosed space. This fact was demonstrated accidently during the present investigation. A number of adult anopheles, which had been fed experimentally upon cases of malaria, were placed in a large wooden box containing a vessel of water until ready for dissection. Unfortunately a large number of small red ants obtained access to the box and devoured nearly every mosquito, attacking even those that had settled on the surface of the water for the purpose of depositing their eggs.

183. But though a large number of adult mosquitoes are being constantly destroyed by natural enemies, it is probable that this loss is small compared to that occasioned by the natural enemies which prey upon the insect in its larval state; and the examination of collections of water containing mosquito larvæ usually shows the presence of other aquatic larvæ and insects which help to reduce their number very greatly. Mention has already been made in the paragraph referring to *Culex concolor* and *Culex tigripes* of cannibal mosquito larvæ present in Bombay, but in addition to these cannibal larvæ many other natural enemies of mosquito have been met with during the examination of collections of water on the island.

184. Among these a species of water boatmen, belonging to the *Notonectidæ*, is especially common. This aquatic insect may easily be recognized by the fact that it swims on its back. If carefully watched it may be seen to catch and devour numbers of mosquito larvæ both Culicine and Anopheline. A minute water bug which kills anopheles larvæ has also been found in a large number of wells and pools of water infested with mosquito larvæ. This bug, which is of a dark grey or black colour, is only a fraction of an inch in length. It possesses a long suctorial proboscis which is usually carried bent beneath its body. It runs about rapidly on the surface of the water and attacks anopheles larvæ readily. It may be seen to climb upon them at the tail end as they rest quiet on the surface of the water; then it moves cautiously forward as far as the thorax of the larva and inserting its proboscis sucks out the juice of its prey. One small bug about as big as a pin's head has destroyed as many as ten anopheles larvæ in the course of a few hours in the manner described.

185. Certain aquatic beetles belonging to the *Dytiscidæ* and *Hydroplulidæ* are common in Bombay and their larvæ destroy considerable number of mosquito larvæ. Many of these beetle larvæ have been found in the large shallow pools of water common in the centre and north of the island. They vary in size from $\frac{1}{2}''$ to $1''$ or more, possess a whitish, fleshy, somewhat maggot-shaped body, and are provided with three pairs of legs and powerful jaws. The jaws are peculiar, being adapted both for seizing and crushing their prey, and owing to the fact that they are hollow, or groved, serve the purpose of a suctorial apparatus also, by means of which the juices of the victim are rapidly absorbed

One of these predacious larvæ about $\frac{3}{4}$ inch long has been seen to devour fifty larvæ of *N. rossi* successively in a very short time. It seized its victims while swimming, but appeared unable to devour them while it remained in the water, as it did not attempt to do so until it had climbed upon a piece of stick or a leaf. It then raised its head and jaws well above the water and commenced to masticate its prey with great energy, until in a very short time only a small mass of crushed cuticle remained. This it rejected and immediately afterwards began to seek for a fresh supply of food.

186. The larvæ of certain of the May flies or *Ephemeræ* are very destructive to mosquito larvæ. They are present often in enormous numbers in pools and tank containing green weed. If they are closely watched they may be seen to seize and devour anopheles larvæ; and it has frequently happened that mosquito larvæ kept in bottles for breeding-out purposes have been all destroyed owing to the fact that a few small *ephemera* larvæ had escaped notice.

Corethra larvæ, the so-called phantom larvæ, which are known to prey upon mosquito larvæ very readily, have also been met with in Bombay, but they are neither common nor widely distributed.

187. But although mosquitoes suffer very great reduction owing to the attacks of insect enemies, and although the presence or absence of such checks may serve to modify indirectly the occurrence of malaria, it is doubtful if this fact can be turned to any great practical use, for it does not appear likely that much good will be achieved by attempting to stock collections of water with insect life.

But fortunately there are other natural enemies of mosquitoes, the encouragement of which may assist in a solution of he problem of mosquito reduction and malaria prevention. Fish have already been referred to as often preying upon adult mosquitoes; but the number of adult insects destroyed by fish is small compared to the vast numbers of mosquitoe larvæ devoured by them.

188. Some years ago it was stated that the absence of malaria in Barbados was due to the presence of enormous numbers of a species of small fresh-water fish locally known as "*Millions*"; and the suggestion has been made from time to time that these fish should be introduced into India for the purpose of Anopheline reduction. But the introduction of fish of this kind into India is unnecessary, as many species of fish which readily prey upon mosquito larvæ exist in every part of the country. Years ago the late Mr. Aitken experimented with small fish in some of the Bombay fountains and until they attracted the attention of small boys, who found great sport in catching them, they appear to have served the purpose of reducing mosquito larvæ in a few collections of water of this nature.

189. The fish used by Mr. Aitken was a species of *Haplochilus* (*H. lineatus*)* easily obtainable locally from the stream which flows out of the Vehar Reservoir, and in certain pools on the island also, during the monsoon. These fish are known locally by the name "*Piku*", but they were called "*Scooties*" by Mr. Aitken on account of their darting movements. They are quite small, rarely exceeding three inches in length and are remarkable for the possession of a brilliant spot of white on the top of the head, between the eyes. They swim on the surface of the water and may often be seen lying quite motionless apparently watching for the approach of flies and other prey.

190. During the present investigation experiments have been made with fish of this species. Several dozens were introduced into small wells containing anopheles larvæ and it was found that in a short space of time the larvæ disappeared. A number of these fish were placed in *15* wells in Dhobi Talao section each of which contained a considerable number of larvæ of *N. stephensi* (the carrier of malaria in Bombay). At the end of three weeks, on re-examining the wells, scanty larvæ were found in only *two* out of the 15. In these two a number of leaves and flowers had been thrown and apparently the floating matter afforded cover, enabling a few mosquito larvæ to escape the notice of the fish.

* This fish was identified for me by Mr. N. B. Kinnear of the Bombay Natural History Society.

191. In addition to the "*Piku*" a number of local fish of other species have been found to prey readily upon mosquito larvæ. Among these may be mentioned *Polyacanthus cupanus*,* a small fish present in Gowalia tank, *Anabas scandens*,* the climbing perch, which can be obtained in large numbers from tanks and pools on the island and from the mainland, and a species of cat-fish which is found in pools in the bed of streams near Thána. Of these fish *Anabas scandens*, known locally as "*Kazari*", is the most valuable. It is larger than the Haplochilus and, as usually obtained, is from three to six inches or more in length. It is stoutly built, with a large head and well-developed pectoral fins. In colour it varies from yellowish brown to greenish black but there are usually patches of a reddish tinge upon its back. Its eyes are very large and brilliant, coloured bright yellow, with well-marked pupils. It is exceedingly active, readily jumping out of the water after flies and mosquitoes, and it devours mosquito larvæ and pupæ voraciously. About two dozen of these fish placed in a masonry tank four feet square containing about four feet of water, kept the tank absolutely free of mosquito larvæ, although many thousands were added to it every day. *Anabas scandens* has also been tried in wells; and when present in sufficient number has been successful in freeing the water from mosquito larvæ; but in wells containing much weed and floating leaves or rubbish it is not successful as the larvæ have cover. There is little question, however, that in wells kept free of floating matter the presence of a sufficient number of these fish would prevent the breeding of mosquitoes.

192. The species of *cat-fish* mentioned, which has been identified as *Macrones Corsula** var. *Trachacanthus*, is also a useful fish to employ as an anti-mosquito agent. Its presence has been noticed in a certain number of wells in the north of Bombay. The little fish from Gowalia tank, *Polyacanthus cupanus*, is not such an active destroyer of mosquito larvæ as either of the other fish, and as it seems to be exceedingly delicate it is not likely to be of so much use in wells as *Anabas scandens* or the *cat-fish*. The two latter species also appear to be better able to resist a change of habitat than "*Piku*," which does not always thrive in captivity.

193. In conclusion it may be stated that, as a result of the experiments and observations that have been made, there appears to be no reason why fish of the species mentioned should not be successfully employed in protecting many of the small permanent collections of water in Bombay such as wells, fountains, and masonry tanks, from the breeding of anopheles and other mosquitoes, provided that the conditions indicated below are adhered to.

These conditions are:—

(1) The number of fish employed must be sufficient for the task and proportionate to the amount of water to be protected.

(2) The water must be kept free from weed, leaves, flowers and floating matter which might afford cover to mosquito larvæ.

Of course it must be understood that fish cannot be employed in wells which are too foul or stagnant to allow of there being a sufficient supply of oxygen for them. Wells in this condition must be protected in some other manner.

194. *Plants inimical to mosquitoes.—Wolffia arizha*, the rootless-duckweed, may be placed among the natural enemies of mosquitoes. There are three varieties of this minute water plant present in Bombay which differ from one another in the size and shape of the grains. The commonest form is to be seen in the Mint Tank and a number of other collections of water mostly in the north of the island. In this form the plant consists of tiny round fleshy masses about the size of a pin's head and of a brilliant green colour. In another variety the individual grains are oat-shaped instead of round and rather smaller in size. In a third variety the grains are much larger and more flattened and resemble small single leaflets of lemna or ordinary duckweed without the roots. Where the rootless-duckweed is present in large amount it forms a thick scum on the surface of the water and by its mechanical action destroys mosquito larvæ just as a film of oil might do. Mosquitoes will lay their eggs on water containing the weed and young larvæ hatch out and live for a time, because while small they can pass their breathing syphons to the surface between the particles of weed, but larger larvæ die of

* These fish were identified for me by Mr. N. B. Kinnear of the Bombay Natural History Society.

suffocation. Among the wells, tanks and pools of Bombay over 50 have been found in which large amounts of *Wolffia* were present, and in which mosquito larvæ did not exist. In a great many other collections of water a scanty growth of the weed did not appear to interfere with the breeding of mosquitoes and in pools where reeds and large weeds broke the surface film of *Wolffia*, larvæ were to be found with ease. Experiments with the weed *in vitro* showed that its action is purely mechanical. Anopheles larvæ placed in water covered with a layer of *Wolffia* immediately assume an almost vertical position, hanging in the water head downwards in a manner resembling that of *Stegomyia* larvæ. After a longer or shorter interval dependent upon the thickness of the film of weed, the larvæ died and sank to the bottom of the water.

195. Experiments tried with ordinary duckweed (*Lemna*) and *Azolla* were unsatisfactory, neither of these plants appearing to have any effect upon mosquito larvæ. Both *Lemna* and *Azolla* were present in tanks and pools in Bombay and in almost every case mosquito larvæ were found living amongst the weed in considerable numbers.

Section 4.

196. ARTIFICIAL MEANS FOR DESTROYING MOSQUITO LARVÆ.—During the investigation a number of experiments have been carried out with a view of gaining some idea of the most effective larvacides from the point of view both of cost and efficiency. The cheapest larvacide is sea-water. Unfortunately mosquitoes quickly adapt themselves to breeding in salt water; but larvæ that have been hatched out in fresh water die after a few hours, when sea-water is added to the water in which they are living so as to form a mixture containing 75 per cent. of sea-water. Common salt, lime, sulphate of copper and sulphate of iron, destroy mosquito larvæ when added to the water in which they are breeding. Sulphate of copper is the most active of these substances but the cost is prohibitive. Sulphate of iron is active only when the solution approaches saturation.

197. The larvacides most commonly used are crude petroleum (otherwise known as liquid fuel or *pesterine*) and kerosene. Of these kerosene is more effective than *pesterine*, but a mixture of about equal parts of kerosene and *pesterine* is more efficient than either oil by itself. *Pesterine* has the advantage of cheapness, and its colour shows when it has been applied; but it does not spread so easily as kerosene, is more apt to collect in large blobs and is much slower in its action. Unless it is used in sufficient amount and carefully spread, it is of very little use, and as it tends to collect in large blobs with free spaces in between, mosquito larvæ easily escape suffocation. In wells in which many gallons of *pesterine* have been placed, mosquito larvæ have been afterwards discovered, even when there was sufficient oil present to have covered the surface of the water many times over. Kerosene costs more than *pesterine* and is more liable to be stolen but it spreads better on water and is decidedly quicker in its action. Unfortunately like *pesterine* it is liable to be blown to one side of a pool if there is much wind and it may be found necessary to repeat the oiling of a pool three days in succession before all the larvæ and pupæ are destroyed.

198. In a series of experiments conducted in the New Dock Works early in 1909 it was found that of 66 pools of water containing numerous larvæ which were carefully oiled with a mixture of *pesterine* and kerosene, applied to them by means of a spray, 47 contained many live larvæ the following day. They were all treated once more but on being examined again the next day scanty larvæ were found in 22, and after being treated a third time a few larvæ were still present in 7. In another series of 44 pools most carefully oiled by being sprayed repeatedly with a mixture of kerosene and *pesterine*, 12 showed a number of living larvæ the next day. These observations show that where it is a matter of importance, as in the New Dock enclosure, that larvæ should be destroyed thoroughly, it is not sufficient to make a routine application of *pesterine* or kerosene once a week, as many mosquitoes continue to reach maturity in spite of it.

199. During the experimental destruction work in the New Dock it was found that the only way to limit the breeding of mosquitoes there with much

effect, was to divide up the whole area into sections and place a trained Indian in charge of each section, with orders to go round every day and destroy any larvæ he might find. The Assistant Surgeon in charge of these men went round the whole area during the week. The staff was told that their work would be inspected very carefully; and after ten days or a fortnight a surprise visit was paid to the docks. The careful search of about 200 pools conducted during this visit showed scanty *large* larvæ to be present in only 5 pools. Complete absence of larvæ was not expected as ova were continually hatching out and many small larvæ were being produced in this way every day, but the comparative absence of full-grown larvæ and pupæ showed that few of them were reaching maturity.

200. As the result of an enquiry regarding the larvacides in use in Panama, Colonel W. G. Gorgas, U. S. A., the Chief Officer in charge of the sanitation of the Canal Zone, very kindly supplied the following formula and directions for preparing a larvacide, which has been used with very great success at Panama.

"*Gorgas' Larvacide*—

Carbolic Acid, crude ...	...	100 gals.
Resin ...	...	66 lbs.
Solution of Caustic Soda	...	(20 lbs. of the solid in solution).

"The method of manufacture is to place the carbolic acid in a vat and "heat to the boiling point by a steam coil. The resin is then powdered and "added to the acid, is melted by the heat, and goes into solution. During the "process of adding the resin, the mixture being formed is thoroughly stirred "by a paddle fixed on an iron rod in the vat and revolved by a crank. The "Caustic Soda is then added. After heating for two or three minutes a small "amount of the mixture in the vat is tested to see if it thoroughly emulsifies "with water. The emulsion formed is of a dirty white or pinkish appearance. "If emulsification is complete the larvacide is drawn off into barrels, allowed "to cool, and is then distributed to the line for use. The method of use is, to "one part of the larvacide add three parts of water, which forms an emulsion. "This emulsion is then spread on breeding places by the use of the 'Knap-"sack Spray.' The advantages are that the larvæ are readily killed, and "their presence may be discovered in unsuspected places; as on spraying the "mixture on the water, the whitish appearance of the emulsion in contrast "with water brings the larvæ into relief. By this method if larvæ have not "been found on inspection, it is known whether or not to continue the "application of the larvacide by the appearance, or non-appearance, as the case "may be, of the larvæ in the emulsion formed by the larvacide with the water "of the suspected breeding place.

"The objection to its use is that even in very high dilution it will kill fish. "It is also destructive to algæ and to a lesser extent to plant life, which is an "advantage. By the addition of a $\frac{1}{2}$ per cent. solution of arsenic the action "on vegetation is greatly enhanced. A small amount of the larvacide mixed "with the ordinary crude oil is found to be very efficacious on running water. "The carbolic acid used is one that should contain 20 per cent. of phenol and "cresols, and a specific gravity of not greater than 0·963. The amount of "resin and caustic soda used varies according to the quality of the crude "carbolic acid, and each shipment of carbolic acid must be tested as to "the amount of resin and caustic soda used before the entire lot is converted "into larvacide. As the crude carbolic varies greatly, each shipment must "be tested. The cost of the larvacide manufactured at Ancon is about 14½ "cents per gallon, United States Currency."

201. Owing to the fact that it was impossible to obtain crude carbolic acid in Bombay of the kind specified by Colonel Gorgas, it was found necessary to modify the formula considerably in order to prepare a suitable carbolic emulsion for experimental use. The crude carbolic acid obtained had a specific gravity of 1·040 and was stated to contain 97 per cent. of phenols and cresols. This acid required five times the amount of resin and soda given in

the previous formula and the resulting preparation when cold formed a thick dark brown pasty mass. It was therefore heated up and diluted with three parts of water, when it formed a dark brown treacle-like liquid smelling strongly of carbolic acid. When a little of this solution was added to water it formed a dirty white emulsion.

202. On being tested as a larvacide it was found to be very active, destroying mosquito larvæ readily, even when used in very great dilution. The original solution was made up so as to contain 25 per cent. of the crude carbolic acid. Dilutions of this solution acted upon the larvæ of mosquitoes in the following manner :—

	Anopheles larvæ.	Bulex larvæ.	Stegomyia larvæ.
Emulsion 1—1,000 (=to 1—4,000 of original carbolic acid).	All died in 6 minutes.	All died in 8 minutes.	All died in 8 minutes.
Emulsion 1—5,000 (=to 1—20,000 of original carbolic acid).	All died in 15 minutes.	All died in 20 minutes.	All died in 20 minutes.
Emulsion 1—10,000 (=to 1—40,000 of original carbolic acid).	All died in 5 hours.	Almost no action.	Almost no action.

203. These results compare favourably those given in the following table :—

Larvacidal action of disinfectants.

		Anopheles larvæ.	Culex larvæ.	Stegomyia larvæ.
McDougall's Saponified Cresols.	1—1,000	All died in 7 minutes.	All died in 8 minutes.	All died in 8 minutes.
Do.	1—5,000.	All died in 15 minutes.	All died in 20 minutes.	All died in 20 minutes.
Phenyle ...	1—1,000.	All died in 12 minutes.	All died in 15 minutes.	All died in 15 minutes.
Do. ...	1—5,000.	All died in ½ hour.	All died in ¾ hour.	All died in ¾ hour.
Jey's Fluid ...	1—1,000.	All died in 12 minutes.	All died in 20 minutes.	All died in 20 minutes.
Do. ...	1—5,000	All died in 25 minutes.	All died in 28 minutes.	All died in ½ hour.
Izal ...	1—500.	All died in 6 minutes.	All died in 5 minutes.	All died in 5 minutes.
Do. ...	1—1,000.	All died in 9 minutes.	All died in 9 minutes.	All died in 9 minutes.
Do. ...	1—5,000.	Almost no action.	All died in 4 to 8 hours.	All died in 4 to 8 hours.

204. As crude carbolic acid can be obtained in bulk at a price of about one rupee a gallon or less, an exceedingly cheap and efficient larvacide can be prepared from it. In use it is found to have more action upon larvæ than pupæ, and nearly mature larvæ pupate rapidly on coming into contact with it, so that it is a good plan to combine its use with that of kerosene or pesterine. The original solution mixes with either kerosene or pesterine and very greatly improves their toxic action and their powers of spreading quickly and evenly. This is shown by the following experiments :—

	Anopheles larvæ.	Culex larvæ.	Stegomyia larvæ
Pesterine.			
260 drops to 1 square yard of surface	All died in 12 hours.	Some die and some survive.	Some die and some survive.
Mixture of Pesterine and Kerosene in equal parts.			
260 drops to 1 square yard of surface	All died in 1¾ hours.	All died in 3 hours.	All died in 3 hours.
Mixture of Pesterine and Carbolic Solution in equal parts.			
260 drops to 1 square yard ...	All died in ½ hour.	All died in ¾ hour.	All died in ¾ hour.

205. It may be remarked that the above experiments were conducted in the dry weather. There is some ground for assuming that the effect of larvacides is greater upon mosquito larvæ hatched in the rainy season, as in a previous series of experiments carried out in the rains, larvæ died more quickly, in the case of every larvacide used. It would appear from this that dry weather larvæ are naturally more resistant to adverse influences than those produced in the rainy season.

206. A further series of experiments were made with non-poisonous larvacides—Malachite green and a new preparation "XeX"* prepared by a Swiss firm and available in Bombay. Malachite green destroys mosquito larvæ in dilutions as low as 1—25,000 in about 24 hours. Unfortunately the brilliant bluish-green colour it gives to water is highly objectionable and water treated with it does not appear to retain its larvacidal properties very long.

207. XeX green has been experimented with in Italy and in Ceylon and appears to have given satisfaction. It is especially useful in view of the fact that animals can drink water containing it without ill effect. As supplied it is in the form of a thick paste of a greenish brown colour. It mixes fairly easily with water, forming a dirty yellowish solution.

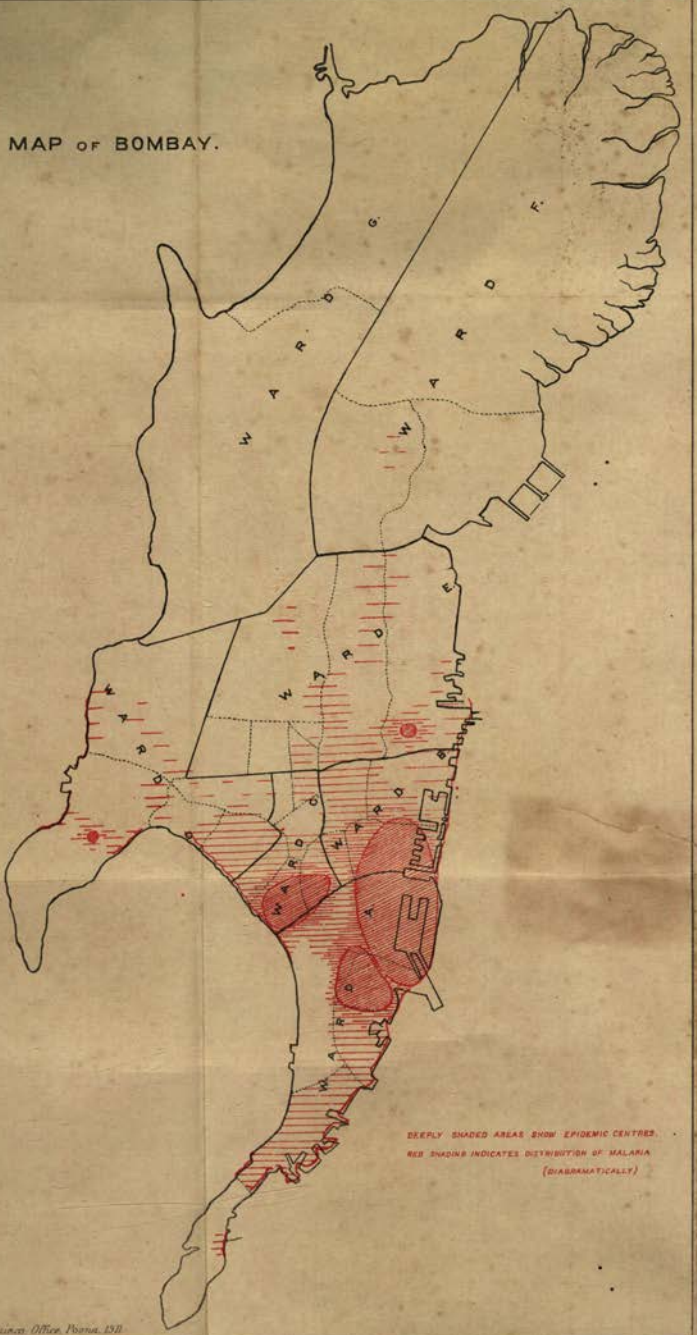
Experiments with larvæ *in vitro* gave the following results:—

	Anopheles larvæ.	Culex larvæ.	Stegomyia larvæ.
XeX Green.			
Solution 1—1,000 ...	... All died in 20 minutes.	All died in ½ an hour.	All died in ¾ hour.
Solution 1—4,000 ...	... All died in 2½ hours.	All died in 3 to 4 hours.	All died in 3 to 4 hours.

A small pool containing mosquito larvæ was sprayed with a fairly strong solution so as to form approximately a solution of a strength of about 1—1,000. On the following day all the mosquito larvæ were dead. These experiments appear to show that the new larvacide is likely to be of service especially where toxic larvacides cannot be used. At present there is no data to show how long water once treated remains toxic to mosquito larvæ.

* Samples were kindly supplied by Messrs. Volkart Brothers of Bombay.

MAP OF BOMBAY.



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CHAPTER VI.

BRIEF SURVEY OF THE FACTORS WHICH INFLUENCE MALARIA IN BOMBAY.

208. A consideration of the facts that have been discussed in the foregoing chapters indicates that there is no direct relation between the climatic conditions of Bombay and the occurrence of malaria, for though the climate in every part of such a small island must be almost identical in character, malaria is prevalent in some parts and almost absent in others. Neither is it possible to trace any relation between the soil and malaria for a similar reason. No relation can be traced also between cultivation and malaria in Bombay, for where there is most cultivation there is least malaria and the existence of rice lands and palm groves in the north of the island has not rendered these parts malarious. As has been previously pointed out, the low-lying, undrained and swampy parts of Bombay are less malarious than the parts that have been longest drained and that as a rule are not liable to flooding and it follows that little direct relation can be traced between the height of sub-soil water and malaria in Bombay.

209. Thus in Bombay malaria presents a complete contradiction to many of the commonly accepted generalizations regarding the disease. But on the other hand when the presence of malaria-carrying anopheles and their breeding places are carefully enquired into, it is seen that there is a remarkable correspondence between them and the presence of malaria on the island.

210. Nowadays the terms "malarious country" and "malarious climate" are not really accurate and their continued use gives rise to a certain amount of confusion in the minds of those who do not realize that, when a place or climate is spoken of as being malarious what is really meant is that, many of the people are infected with malarial parasites and that conditions are suitable for the existence of species of mosquitoes capable of carrying the disease.

211. As malaria is due to the presence of a minute animal parasite which passes one stage of its existence in the blood of man and another in the body of a female anopheles mosquito of a suitable species, the occurrence of malarial disease in any place is dependent upon the presence of the three factors :

(A) Man,

(B) The malaria parasite,

(C) A suitable species of anopheles,

and in general it may be said that the severity of malaria depends upon the numerical relations of these different factors.

212. Broadly speaking it may be said that in malarious places the effect of the disease among the population is proportionate to the number of malarial parasites actually present. If there are only a few million parasites distributed among a thousand people, there will be only a few cases of mild malaria, whereas if the total number of parasites is many million times greater both the number of sufferers and the severity of the cases will be proportionately increased.

213. The number of malarial parasites present in a community tends to increase or decrease under certain conditions.

(1) The presence of a large number of anopheles mosquitoes of a species capable of carrying malaria tends to produce an increase in the number of parasites owing to the spread of infection, whereas a reduction in the number of suitable anopheles tends to produce a fall in the total number of parasites due to a lessened spread of infection.

(2) Among infected people, climatic, social and economic and other conditions, if favourable to man, tend to reduce the total number of parasites, by increasing the powers of resistance of the persons concerned; whereas if unfavourable they may cause an increase in the number of malarial parasites by lowering the powers of resistance of these persons.

Section 1.

214. It is necessary therefore to consider in some detail both the conditions which may influence the number of malaria-carrying anopheles and those which may influence man's powers of resistance to malaria.

The conditions relating to anopheles, which may influence malaria, are:—

(1) Species of anopheles.
(2) Number of anopheles.
(3) Character of breeding places—
  (i) Drainage.
  (ii) Swamps.
  (iii) Rice growing and Irrigation.
(4) Rainfall.
(5) Other climatic conditions—
  (i) Temperature.
  (ii) Humidity.

Conditions which influence man in relation to malaria—

(1) Climate.
(2) Economic condition.
(3) Social condition.
(4) Overcrowding.
(5) Temporary aggregations of labour (soil disturbance).
(6) Education.
(7) Treatment.
(8) Migration.

215. *Species of Anopheles.*—We have already seen in the chapter on mosquitoes that there are seven species of anopheles in Bombay which, from the point of view of the spread of malaria, may be divided into three groups.

Known dangerous carriers of malaria.

(1) *N. stephensi, M. listoni, M. culicifacies, and N. filiginosus.*

Possible carriers of malaria.

(2) *N. jamesi and M. barbirostris.*

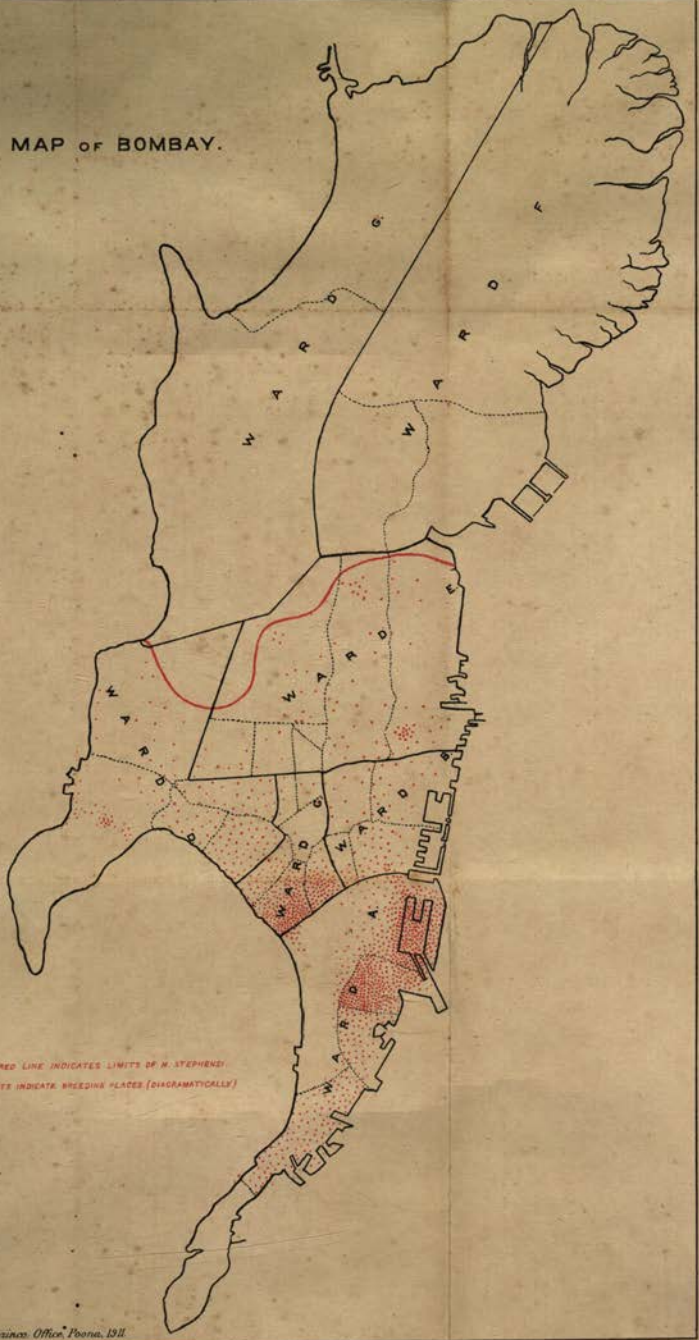
Non-carrier of malaria.

(3) *Nysso-M. rossi.*

If we compare a map showing the distribution of mosquitoes of group 1 with another map showing the distribution of malaria in Bombay, it becomes apparent at once that there is a close relationship between the existence of malaria among the population and the presence of the known carriers of the disease. In the case of group 2 no such definite relation is apparent, and though possibly *N. jamesi* may be concerned in the spread of malaria to some extent the fact that this mosquito often occurs in association with either, *N., stephensi* or *M. culyfacies* or *listoni* obscures the relationship. It appears reasonably to assume that *M. barbirostris* is not responsible for the spread of malaria in Bombay because the places in which it occurs abundantly, *i. e.*, Mahim and other parts in the north of the island, show little evidence of infection. As regards *Nysso-M. rossi* which is present in large numbers all over the island, there is conclusive evidence that it does not carry malaria in Bombay and as might be expected no relation can be traced between its presence and the occurrence of malaria.

216. *Number of dangerous Anopheles and Malaria in Bombay.*—Broadly speaking a definite relationship can be traced between the amount of malaria present in different localities and the number of dangerous anopheles present there as judged by the findings of larvæ and the occurrence of breeding places. In Esplanade and parts of the North Fort where very large numbers of breeding

MAP OF BOMBAY.



Govt. Photozinco. Office, Poona. 1911.

places of *N. stephensi* exist and where adult insects can be caught fairly easily the index of malarial infection is very high and in Dhobi Talao where breeding places are also numerous both the spleen index and parasite index show malaria to be exceedingly prevalent. In B ward the portion most affected with malaria adjoins the New Dock enclosure where many breeding places of *N. stephensi* occur. In South Fort, Colaba and Market Sections breeding places of *N. stephensi* are more widely scattered and malaria is present in lessened amount. In Dongri, Umarkhadi, Khara Talao, Kumbarwada and the greater portion of Bhuleshwar, breeding places are not very numerous but it is possible that they existed there in greater number previously, especially in areas which have been demolished by the Improvement Trust. In Fanaswadi Section, Girgaum, a portion of Bhuleshwar, Chowpati and Khetwadi, there are a number of breeding places but they are rather widely scattered and with few exceptions appear to harbour comparatively scanty numbers of *N. stephensi.* Further to the north with the exception of the neighbourhood of the reservoirs at Malabar Hill and Bhandarwada, the number of malaria-carrying anopheles, as judged by the occurrence of their breeding places, diminishes very greatly; and in the extreme north *N. stephensi* is absent and only a few breeding places of *M. listoni* and *M. culicifacies* exist. The number of the latter mosquitoes too appears to be very limited as their larvæ are always found in very scanty numbers.

217. *Character of Breeding Places of Malaria-carriers in relation to the prevalence of Malaria in Bombay.*—In the Chapter on mosquitoes it was stated that the commonest breeding places of malaria-carrying mosquitoes were open wells; and in particular 65 per cent. of the breeding places favoured be *N. stephensi* were of this character. Of these wells, the ones situated inside dwelling-houses are usually the most prolific producers of *N. stephensi*, whereas those in the open, although frequently infected, often show only scanty numbers of larvæ. Pools of water do not appear to be greatly favoured by *N. stephensi* and other malaria-carrying anopheles in Bombay; and with the exception of the surface pools which occur in the New Dock Works and some of the neighbouring yards, which are prolific breeding places during the monsoons larvæ are never very plentiful in them. But tin-pots, tubs and other small collections of water appear to be very suitable breeding places, for when the larvæ of *N. stephensi* has been found in such situations it has generally been present in considerable numbers. Cisterns vary very greatly as regards their output of *N. stephensi.* In the monsoon they often produce considerable numbers but, when the weather is warm and dry, the water in cisterns whose sides are exposed to the sun often becomes quite hot and this does not appear to be favourable to mosquito larvæ.

The existence of favourable breeding places of the malaria-carriers is of course directly responsible for their numbers, and in this way a more or less direct relationship can be traced between the character of breeding places and the prevalence of malaria. As has already been pointed out, the existence of swamps and large numbers of pools, the lack of drainage, and the continuance of rice cultivation in the north of the island does not appear to increase malaria to any appreciable extent, as shown by the low spleen and parasite indices observed there.

218. *Rainfall and Malaria in Bombay.*—The malarious season in Bombay begins shortly after the commencement of the rains and continues for a certain period after they have ceased. Cases of malaria usually show an increase in July and infected anopheles are met with in considerable numbers in that month. It is difficult to trace any relation between the amount of rainfall and the prevalence of malaria. There is little evidence to show that years of excessive rain have been specially malarious and in 1907 which had a rainfall of 100 inches, although there was a considerable amount of malaria, there was not nearly as much as in 1908, which had a short rainfall of only 51 inches. In both 1909 and 1910, although the rainfall exceeded that of 1908, malaria was much less than in 1908. The explanation of this want of relation between the amount of rainfall and prevalence of malaria is to be sought in the fact that the majority of the breeding places of the malaria-carrying anopheles of Bombay

are little influenced by rain. It may be remarked also that in 1909-1910 many of the breeding places in the Dockyard, etc., which might be so influenced were treated with larvacides.

Distribution of rainfall probably exerts some influence upon malaria in Bombay. It was observed in July 1910 that during a long break in the rains a larger proportion of sporozoit-carrying anopheles was met with than at any other time, whereas during a period of nearly continuous rain the proportion of sporozoit-bearing anopheles was greatly reduced. It appears probable that the hot sunny weather combined with high atmospheric humidity that usually characterises the breaks in the rains is favourable to infected anopheles, whereas in periods of continuous rain many of the insects perish, being killed possibly by exposure to rain when attempting to lay their eggs.

219. *Temperature and Malaria in Bombay.*—(1) *Heat.* High temperature is favourable to the occurrence of malaria especially when associated with rain; and exposure to a high temperature appears to promote both the onset of symptoms of an infection in man and the occurrences of relapses. In Bombay relapses of malaria often occur at the hottest time of the year and the period of new infection coincides with a period of slightly lower but almost uniform high temperature. High temperature also shortens the larval and pupal stage of anopheles and is favourable to the increase of mosquitoes in the presence of suitable condition of humidity, etc. It also quickens the development of sporozoits in infected mosquitoes.

220. (2) *Cold.* Observation has shown that the parasite of malaria will not develop in the mosquito at a temperature below 60° Fahrenheit; but the temperature in Bombay rarely falls as low as this and never remain below 65° Fah. for more than a few hours, so that as far as temperature is concerned infection of anopheles can go on all through the year. The onset of the colder weather in Bombay, as in other malarious countries, is often the cause of sudden small outbreaks of malaria due to the maturing of infections contracted at an earlier period; and the occurrence of relapses is also favoured by cold. Infections which have remained latent often appear when the diurnal variation of the temperature increases suddenly, owing possibly to the fact that the resisting power of infected persons may have been slightly reduced by the change. In Bombay whenever the variation between the night and day temperature exceeds 10 or 12 degrees cases of malaria increase in number, a fact which is very apparent each October.

221. *Atmospheric Humidity and Malaria in Bombay.*—The malarious season of Bombay coincides with the period of highest and most uniform atmospheric humidity, and it is possible that this is due partly to the fact that excessive humidity is favourable to insect life and partly because it acts as a depressing influence upon man. When the humidity of the atmosphere rises, mosquitoes become very active and bite more readily than at other times and it is probable that this condition conduces to their longevity also. There is the further possibility that atmospheric humidity may influence the development of malaria parasites in the body of the mosquito. Infected anopheles appear to become numerous in Bombay only during periods when atmospheric humidity is uniformly high and in periods when it is low or when there is a great diurnal variation, infected anopheles tend to disappear.

Section 2.

222. *Conditions affecting malaria by their influence upon man.*—The conditions which increase malaria by influencing man are those which tend to predispose him to infection or to bring about relapses in persons already infected. In either case the result in a malaria-infected community will be the same, namely, an increase in the total number of parasites present. But although the various factors which may come into play in this connexion are important it must be pointed out that they have nothing to do with the origin of malaria; they can only modify it when it is present either by increasing or reducing its severity.

223. *Social conditions in relation to malaria in Bombay.*—It has often been observed in malarious places that communities of low social status suffer more severely than those of higher standing and the reason for this is easily understood, because all parasitic diseases tend to occur more frequently and to

act most intensely among the poorer and more ignorant classes. But in the malarious parts of Bombay although those of low social status such as sweepers and others suffer greatly from malaria, those of the better social standing are by no means exempt from the disease. In particular the Pársis (as has already been pointed out) who as a community are comparatively well off, are better educated and possess a higher standard of living than many other classes in Bombay, often show greater evidence of malaria. This is especially the case among those who reside in the North Fort and Dhobi Talao. In these two localities Pársis are probably more exposed to malarial infection than the other classes of the community by reason of the open anopheles-infested wells that are to be found inside many Pársi dwelling-houses.

224. In other parts of the City, especially in portions of the Fort and Colaba, Europeans and Indians of good social standing often contract malaria.

One reason for this is the wide distribution of breeding places of the malaria carrier, but another cause is the fact that in almost all the modern flats, which are largely used as places of residence by Europeans and better class Indians, quarters for native servants are constructed under the same roof. It frequently happens that in these quarters, which are often very small and cramped, a low-class native population is harboured as great or even much greater in number than their employers. Among these people malarial infection often exists to a considerable extent and it follows that, should *N. stephensi* be breeding in the house cisterns or in the neighbourhood and adult insects gain access to the houses, all the factors necessary for the spread of malaria are present. This partly explains the frequent occurrence of malaria among people of good social standing in Bombay.

225. *Overcrowding in relation to Malaria in Bombay.*—In the foregoing paragraph one effect of overcrowding has been noticed, but there is an even more important one to be considered. It has frequently been stated that malaria tends to diminish in proportion as the density of a population increases. The explanation is to be sought in the comparative absence of breeding places of ordinary carriers of malaria usually met with in centres of dense population. But in Bombay many areas which possess populations of more than 200—400 people per acre are most malarious. This is explained by the domestic habits of *Neocellia stephensi* and the peculiar character of the breeding places selected by it. Provided the carrier of malaria is present, density of population tends to increase rather than diminish the intensity of infection, for anopheles have no difficulty in obtaining food and shelter in the crowded dwellings, and an infected insect has far greater chances of biting large numbers of different people in a short time when from five to twenty are sleeping in a single room, than in places where the population is comparatively sparse. Overcrowding in Bombay also leads to many thousands of people sleeping out-of-doors and these persons are specially exposed to the attacks of mosquitoes. In parts of the Fort near the New Docks hundreds of people may be seen almost all the year round sleeping out-of-doors; and a large proportion of these people are infected with malaria.

226. *The effect of Economic conditions on malaria in Bombay.*—In one of the earlier paragraphs of this report attention was drawn to the economic conditions of the population and in another paragraph in discussing epidemic malaria reference was made to the sudden rise of prices in Bombay during 1907 and 1908. The importance of economic conditions in modifying malaria has only recently been recognized although it has long been known that the disease tended to diminish in times of great prosperity and to increase in times of scarcity. Christophers* as the result of investigations carried out in the Punjab has shown that the occurrence of epidemic malaria there is often closely associated with two factors, abnormally heavy rainfall and high prices of food. When these two conditions are present at the same time, as in 1908, epidemics occur, but neither heavy rainfall nor high prices produce the same result when acting alone. The occurrence of heavy rainfall in the Punjab always results in an increase in the number of malaria-carrying anopheles, but in Bombay, as has been pointed out in another paragraph, the amount of rainfall does not appear

* *Vide* "Paludism" No. 2, February 1911.

to generally influence the anopheline factor. But when from any cause the number of malaria-carrying mosquitoes in Bombay is increased the occurrence of a coincident rise in the prices of the necessaries of life would reproduce on a small scale the conditions shown by Christophers to lead to severe epidemic malaria in the Punjab.

As we have already seen prices of food and fuel rose to an abnormal height in Bombay during latter part of 1907 and again in 1908. This rise occurred at the malarious season of the year and if we assume that the carrier of malaria was specially abundant in 1908 the coincidence of these conditions would explain the severe outbreak of malaria in that year.

227. This is not the first occasion in which high prices appear to have influenced the occurrence of outbreaks of malaria in Bombay. In 1757 at the time when an outbreak of disease, probably malarial in nature, occurred among the labourers employed upon the fortifications, and affected the general population, prices of food were so high, that the workmen petitioned the authorities to supply them with grain from the Company's stores; and a little later, the shoe-makers who supplied the troops appealed to be allowed to increase their charges on the grounds that rents had gone up from Re. 1 and Rs. 1-8 to Rs. 3 and grain from Rs. 1-4 to Rs. 2-8 a maund.

228. The effect of sudden rises of prices upon a considerable proportion of the poorer households in Bombay has been traced in the introductory chapter; but the influence which it may exert in increasing malaria among an already infected population will be better understood when it is pointed out that among troops and bodies of labourers infected with malaria observation has shown that abstinence from food, prolonged only a few hours beyond ordinary meal-times, is sufficient to bring about many relapses of malaria a few days afterwards. And an epidemic of relapses in places, where the carrier of the disease is present, is the precursor of an abnormal number of new infections. A rise of prices in Bombay always means increased economic pressure among the poorer classes, which leads to privation and a consequent dimination of their powers of resistance to disease; and in parts of the City where malarial infection is present and a sufficient number of the carriers of the disease exist a vicious cycle is thus set up, privation leading to relapses, and relapses causing an increase of new infections, and so on, until an epidemic of malaria is produced.

229. *Soil disturbance and outbreaks of Malaria.*—For many years it has been recognized that outbreaks of malaria frequently occurred in association with excavation and other works involving soil disturbance; and these observations led to the old theory that the virus of malaria was present in the soil and that over-turning the soil allowed it to escape and diffuse into the atmosphere with the result that epidemic outbreaks occurred. Unfortunately many people still cling to this idea and it is necessary on this account to try and make clear the sequence of events which leads to outbreaks of malaria often more or less directly associated with construction works in the tropics.

230. In the East the coolie labourers employed on such works are drawn almost entirely from the poorest and most ignorant classes of the population; they are often brought long distances and set down in a country where the climate, and even the food obtainable, differ greatly from that to which they are accustomed. If housed at all they are generally crowded into temporary huts, but frequently they are left to find what shelter they can. Often they have no one to look after them when sick and no means of obtaining food when for any reason they are unable to work. Their work is arduous and their pay small; and as they generally try to save money for the support of dependents at home it is no uncommon thing to find them attempting to exist upon a miserably insufficient diet. Camped, as they usually are, upon the site of the work, their surroundings are almost always highly insanitary, for there is rarely any pretence at a conservancy system and sometimes no proper water-supply; and if much earth work is going on, the numerous pools of water formed during the rainy season speedily become the breeding places of countless swarms of mosquitoes. In these circumstances it is not surprising that coolie labourers on large public works should be decimated by outbreaks of epidemic disease, tending to increase in severity as the work progresses. But whatever happens

to the coolies the work has still to go forward, so that as long as it is in progress there is continual imigration of new labourers to fill the gaps caused in the labour force by sickness, desertion and death. This continual imigration is a further source of mischief, for the constant introduction of gangs of susceptible new comers into camps which already are hot-beds of disease, increases the trouble just as the addition of fuel to a glowing fire increases the blaze.

231. The conditions briefly described above or some slight modification of them are the cause of the epidemic outbreaks almost universally attributed to soil disturbances. But some of the minor outbreaks attributed to this cause are merely the occurrence of relapses among labourers already infected, as the result of arduous work or exposure to the sun and rain. If such epidemics of relapses occur among the labourers of a labour camp where carriers of malaria abound new infections will increase proportionately.

232. A consideration of these facts shows that temporary aggregations of labourers may often be a most potent cause of increased malaria in places where the infection and the carrier already exist; and the occurrence of even quite small labour camps is sufficient to produce an appreciable effect. In Bombay in 1909 a small collection of coolies belonging to an Indian contractor were working in a part of Chowpatti. There were only about 23 of them and they were housed in the most miserable of makeshift shelters. They had been working there for some time, and there were a few open wells close by infested with larvæ of *N. stephensi*. Examination of the blood of these people showed that 35 per cent. were infected with malaria parasites, an index far exceeding that of Chowpatti as a whole. Not only did these people suffer from malaria, but a foreman and an overseer who belonged to Bombay and who had a small office on the site of the works, in which they often stayed till late at night, both contracted malaria, most probably in the course of their work.

233. In the case of the New Dock Works large numbers of labourers were brought together and many of them were camped down on the site of the work. A number of temporary frame huts were provided for these people, but besides these, many little shelters were built here and there by the coolies themselves. A good supply of water was laid on from the City mains, latrines were provided, and arrangements made for medical treatment of the sick. It is probable that but for these precautions disease would have been even more prevalent amongst the labourers than it was; but there is no reason to suppose that special precautions were adopted against malaria at the commencement of the work. It is probable that if it had been generally known that malaria was prevalent in the North Fort, which adjoins the dock site, efficient preventive measures would have been instituted from the first; and the most simple measure would have been the removal of the labourers from the site of the work after night-fall.

234. It is recorded that, when the road between Colombo and Kandy was being constructed a fearful epidemic of malaria occurred amongst the labourers employed, who were encamped along the site of the line. Villages near the line also suffered severely. Because of this outbreak, arrangements were made at a later period, during the construction of the railway, to convey all the labourers to and from the work by special trains. The labourers were housed in Colombo and Kandi away from the site of the work. As a result of this measure an outbreak of disease was avoided.

235. *Education in relation to Malaria in Bombay.*—Celli has pointed out that education has a most important influence in modifying the severity of malaria. Usually other things being equal malaria tends to be most prevalent among the poorest and more ignorant classes of the community, and in proportion as the spread of education leads people to seek proper treatment for the disease and to adopt methods for its prevention malaria will become less and less common. At the present time large numbers of the educated citizens of Bombay are familiar with current ideas regarding malaria and it is probable that the majority of them on occasion seek the advice of qualified medical practitioners for their children and themselves and adopt minor precautions against malaria, such as the use of mosquito nets, etc., at night; though it is probable that mosquito nets are more often used because of the discomfort of mosquito bites, than with the idea of escaping malaria.

236. But in regard to public measures of prevention directed against malaria a great deal has still to be learned and it is often a difficult matter to convince otherwise well informed people that an open well may be a danger not only to themselves but to their neighbours. This fact explains in part the persistence of malaria in Bombay, for the continued existence and spread of the disease in the City would be impossible, but for the facilities afforded to the breeding of the carrier, *N. stephensi*, in wells and other collections of water which are under the control of the property-owning and educated classes of the community.

237. *The Effect of Treatment upon the Prevalence of Malaria.*—It has sometimes been supposed that one of the main factors in causing the disappearance of malaria from Great Britain was the gradual adoption of efficient methods of treatment for the disease; and there is considerable evidence to support the view that in proportion as communities make use of quinine and skilled treatment the disease tends to become less prevalent. Bombay is favourably situated in possessing a number of medical institutions and also very many trained physicians and chemists and druggists; and a large number of cases of malaria are treated by them every year. Every case of malaria adequately treated lessens the chance of the spread of the disease and though it is not possible to estimate the exact effect which is produced upon the malaria of the City by the treatment of many thousand cases of infection, there is little question that it exerts a very strong ameliorating influence. But there are still a large number of people who are not reached by treatment and until they are induced to seek it of their own free will or to receive it when offered, they will remain a danger to the remainder of the population so long as malaria is uncontrolled by public measures directed against the anopheles mosquito which carries it.

238. *Migration and Malaria in Bombay.*—It has been a favourite theory in Bombay that malaria is an imported disease. No doubt a certain proportion of those who come into the City every year from the Presidency districts and other parts of India, carry malaria parasities with them; but there is no reason to suppose that a very great amount of infection is imported in this way. The migration into the City from the more malarious districts of the Presidency is very small; there are few immigrants from Sind, Panch Mahâls and Kánara which are probably the most malarious districts; and neither the Konkan nor the Deccan as a whole are very malarious.

239. The examination of people newly arrived from their country has rarely shown evidence of much malaria amongst them, except in the cases of vagrants, among some of whom enlarged spleen is not uncommon; whereas among Bombay born people, such as the Pársis, malaria is common. As has already been pointed out the spleen index indicates that imported malaria is not a serious matter in Bombay. The spleen census, conducted in an area including 5/6ths of the island, which harbours 2/3rds of the total population, gave an index of only 1·9 per cent.; whereas in the remaining 1/6th of the island to the south of this, an area which harbours 1/3rd of the population, the spleen index was nearly 15 per cent.

240. But although there is no reason to suppose that much malaria is imported from without, internal migration from the south to the north of the island is responsible for a certain amount of the infection present there. Quite recently many thousand people have been displaced from some of the malarious localities in the City and there is little question that a proportion of the enlarged spleens which raise the spleen index of the north of the island to 1·9 per cent. belong in reality to the south of Bombay.

241. The fact that malarial infection cannot spread in the absence of the carrier of the disease is often overlooked. If every person who entered Bombay was infected with malaria there could be no spread of the disease if the comparatively few breeding places of dangerous anopheles were efficiently controlled.

242. In conclusion it may be pointed out that, there is evidence that the amount of malaria contracted locally is many times in excess of that introduced into the island from without; and there is little question that from the point of view of malaria prevention the importation of malaria infection into Bombay may be ignored.

PART III.—PREVENTION OF MALARIA IN BOMBAY.

CHAPTER I.

HISTORY OF MALARIA PREVENTION IN BOMBAY.

Section 1.

243. THE PAST HISTORY OF MALARIA PREVENTION IN BOMBAY.—The history of malaria prevention in Bombay dates from quite recent times, for although much has been done in the past two centuries to reclaim the "drowned lands" in the island, embankments having been built here and there, many swamps and marshes having been filled in and much low-land raised above flood level; and although much of this work was originally undertaken with the view of improving the health of the City, it is questionable if it can be said to have been specially directed against malaria.

244. In 1841 the two Napiers cleared a considerable area of the foreshore at Colaba of mangrove bushes in the hope of reducing malaria, which had become so severe during the construction of the Colaba Causeway as to seriously affect the health of the troops. This measure was undoubtedly directed against malaria; and there is reason to believe that after it was carried out the disease diminished in Colaba, though whether as a result of the work or merely because of the completion of the Causeway, the construction of which had caused the epidemic, it is difficult to determine.

245. It is not possible to class the numerous drainage schemes which have been carried out in Bombay since 1863 as anti-malaria measures; for although it was at one time believed that the undrained areas in the island were malarious and that the construction of sewers and storm-water drains would render them more healthy, there is no evidence that malaria was influenced in the slightest degree by the drains and sewers; and the fact that many parts of the City now severely affected by malaria are among those which have been longest drained, while the northern portion of the island which is totally undrained is almost free of the disease, negatives this view.

246. The appointment of a Committee by the Corporation in September 1901 to consider certain matters regarding the presence of Anopheles mosquitoes and the measures which might be taken to reduce or suppress them, appears to have been the first occasion on which the adoption of specific measures against malaria on the lines laid down by Ross received consideration in Bombay. At that time it was assumed that malaria was responsible for a very large amount of sickness and considerable mortality in the City.

The Committee urged the Corporation to attempt the destruction of every kind of mosquito, and stated that they "Were prepared to recommend the Corporation to sanction liberal expenditure, if necessary, to make these measures effective, but as the Executive Health Officer believes that he will be able to carry them out with the existing establishment, he may be requested to endeavour to do so, and to report at the end of three months if he finds that a special staff will be required." As a result of their recommendations certain measures were undertaken.

Apparently it was soon found necessary to augment the existing staff, for it is recorded in 1902 that for each ward of No. 1 Division of the City one mosquito gang, consisting of a sub-inspector and four men, was formed. No. 1 Division of the City at that time consisted of three wards A., B., C. with a total area of about 3·8 square miles and a population of 376,624 and the mosquito gangs for work in this area numbered 3 sub-inspectors and 12 men. The total wages of this staff at present rates would amount to about Rs. 260 per month (or about £208 per annum), These gangs found Anopheles larvæ chiefly in fountains, drinking troughs, tubs and buckets, open cisterns and certain drains. Culex larvæ they found chiefly in wells, gullies and stormwater catch-pits.

The Executive Health Officer records that holes in the ground were filled where possible; open drains cleared; drinking troughs, tubs and buckets emptied once a week; fish were placed in fountains; and other breeding places were treated with a mixture of tar and kerosine.

247. In March 1903 the Corporation asked for a report of the work done since the adoption of the resolution regarding anti-mosquito measures the year previously. A list of 855 places dealt with, including pools, ditches, wells, fountains, quarry-holes, etc., was submitted to them and the Executive Health Officer stated that work on the lines laid down in 1902 was being continued. In the same year (July 1903), the Corporation resolved that the Municipal Commissioner should be requested to organize a regular system of cleaning public wells and tanks at fixed intervals. But in August of the same year the Executive Health Officer reported that, no good so far as mosquito larvæ are concerned will be obtained by periodical cleansing such as the Health Department was able to do. He recommended that the Heads of Departments, in whose charge the wells and tanks were, should be asked to arrange for their systematic cleansing.

248. In 1904 the Executive Health Officer recommended the filling up or covering of wells or the use of fish in them; but the number of wells thus dealt with is not stated. In the Health report for 1904 it is not stated whether the special staff appointed for anti-mosquito work in 1902 was continued during that year.

249. In 1905 owing to the prevalence of malaria in the quarters of the Inspector at Malabar Hill Reservoir, wire gauze was fixed to the verandahs and windows at a cost of about Rs. 750. In August 1905 the Corporation passed a resolution asking the Municipal Commissioner to report on the probable cause or causes of the reputed unhealthiness of the houses in the neighbourhood of the reservoir and those in the vicinity of the nullah between the reservoir and Nepean Sea Road, and also to report what steps he proposed taking to remove the cause of unhealthiness and the cost thereof. The Executive Health Officer recommended that the open channel drain for waste water from the water works should be continued higher up and that all the places from whence water oozed should be drained. He advised the abolishing of the Dhobi Ghat also and suggested that residents in the affected area should be given a leaflet explaining how to prevent the breeding of mosquitoes. In December 1905 the Municipal Commissioner directed the Health Officer to undertake the work of cutting away undergrowth and connecting the sand washing tanks with the existing channel drain. This work was carried out by January 1906. Towards the end of 1905 the Corporation moved a resolution regarding the supposed increasing prevalence of malaria and other fevers in the city and as a result Government was approached and a Special Committee was appointed in March 1906 to go into the matter.

250. During 1906 although the destruction of mosquitoes was undertaken in various localities there does not appear to have been any measure of importance carried out against malaria. A pond at Mahaluxmi and the storm-water reservoir are mentioned as having been dealt with, but this was on account of the mosquito nuisance and not because of malaria.

251. In 1907 the Corporation sanctioned the expenditure of a considerable sum of money for the repair of Bhandarwada Hill Reservoir at Mazagaon, which had been subject to serious leakage for some time. The leak gave rise to springs and streamlets near the base of the hill and these became the breeding places of Anopheles mosquitoes (*M. listoni*), the presence of which caused the spread of malaria among residents in the neighbourhood. During the same year complaints were received regarding the prevalence of malaria in Frere Road and Chowpati; and as a result a certain amount of preventive work appears to have been done in both areas. The Health Officer records, regarding Frere Road, that all the storm-water catch-pits in the locality as well as the side walls of gullies were treated with pesterine (crude petroleum) at frequent intervals; and that stagnant pools in the new Dock compound were also pesterined. At Chowpati also similar measures were adopted.

252. In 1908 the Special Committee, appointed by Government in 1906 to enquire into the supposed increasing prevalence of malaria and other fevers in Bombay, presented their report; but in this report the question of malaria was dismissed very briefly, and beyond referring to the leaky condition of the reservoirs and filters at Malabar Hill and Bhandarwada Hill as a cause of malaria in those localities, and advising that steps should be taken to remedy this condition, no recommendations were made regarding the adoption of specific measures against malaria. But in the same year malaria became increasingly prevalent in Bombay, a serious epidemic being reported from Frere Road. The Executive Health Officer, on being asked to report upon the matter, stated that all stagnant pools in the new Dock compound were being frequently treated with pesterine by the Municipality as in 1907; and he recommended that the Port Trust should be asked to take up the question also.

253. In July 1908 the Corporation passed a resolution to the effect—

> "That the Commissioner be requested to report whether action under Section 377 or any other Section of the Municipal Act cannot be taken against those whose premises in the Frere Road, Fort, have been known to be in such unwholesome or filthy condition as has proved dangerous to the health of the inhabitants of that locality, and especially the Port Trustees in respect of the large area of marshy land near the New Docks which is, in the opinion of the Health Officer and the Executive Engineer, the cause of the prevalence of malarial fever in Frere Road and, if so, to state the necessary action and to report the result to the Corporation."

254. Following upon this the Municipal Commissioner addressed the Port Trust, and as a result the Agent of the New Dock Contractors undertook to drain off or fill in as many pools on the high ground as possible and treat the remaining one with pesterine, and also to cut down the grass. The Acting Executive Health Officer also addressed letters to the Presidency Executive Engineer regarding pools in the compound of the new General Post Office in the Frere Road, the Engineers of the G. I. P. and B. B. and C. I. Railways regarding pools and quarry holes in the railway yards adjoining Frere Road, and to the Physician in-Charge of St. George's Hospital regarding the condition of the hospital compound, which also adjoin Frere Road.

255. On September 17th, 1908, an assistant Sanitary Inspector and four men were deputed for special mosquito destruction work in Ward A. and a Sub-Inspector and four men for similar duties in each of Wards B., D., and E., respectively. The Executive Health Officer stated that these gangs were intended to supplement in a systematic way the work done by the usual sanitary staff in destroying mosquitoes. It may be inferred from the appointment of these gangs for anti-mosquito work late in 1908, that the small special staff appointed for that purpose in 1902 and 1903 had been discontinued in the interval.

256. In spite of these measures a severe outbreak of malaria occurred in the last quarter of 1908, the disease being especially prevalent in the Frere Road, near the docks. The work of the port was greatly interfered with owing to the occurrence of fever among the shipping coolies and staff of the port and the G. I. P. Railway had great difficulty in maintaining their daily complement of trains on account of sickness among their guards and drivers. Owing to the prevalence of malaria many coolies and boatmen left the City—a fact borne out by the statement of the Civil Surgeon of Ratnágiri, who reported that a large number of people from Bombay were suffering from malignant tertian fever.

257. In November 1908 the Bombay Government decided that in view of the serious loss of life and health, and the grave embarrassment that had been caused to the business of the City and the trade of the port, immediate action should be taken to investigate the causes of the outbreak and to devise measures of prevention for the future.

Section 2.

258. THE HISTORY OF MALARIA PREVENTION SINCE 1908.—The recent history of malaria prevention in Bombay may be said to date from the beginning of the enquiry arranged for in consequence of the epidemic of malaria in 1908. In November of that year the Bombay Government decided to depute a Special Officer, to investigate the causes of the outbreak and proposed to associate with him a small Committee representing the chief public bodies in the City. Early in 1909 Captain A. G. McKendrick, M.B., I. M. S., was appointed to conduct the investigation; and a Committee consisting of representatives from the Municipal Corporation of Bombay, the Bombay Port Trust, the City of Bombay Improvement Trust, the G. I. P. Railway Company and the B. B. & C. I. Railway Company was formed for the purpose of carrying out any measures which might appear necessary for the immediate mitigation of malaria.

259. In March 1909 Captain McKendrick, having discovered that there was a very heavy percentage of malaria-stricken persons in the area bounded by Church Gate Street on the south, Hornby and Paltan Roads on the west, the Harbour on the east and Musjid Siding on the north, suggested in view of this fact and in anticipation of a renewal of the malaria epidemic in the autumn of 1909 that it would be wise to take immediate steps to treat with quinine all children in this area affected with enlarged spleen. He therefore approached the Municipal Commissioner and as a result a scheme was drawn up and eventually sanctioned by the Corporation, for the employment of two medical assistants on salaries of Rs. 125 each per mensem and ten compounders on salaries of Rs. 40 each per mensem, for the purpose of a house to house distribution of quinine tablets, in the area mentioned above. The distribution of quinine was commenced in April 1909 and by May 5th Captain McKendrick reported that 1,212 children were under treatment out of 1,496 found to have enlarged spleen in the area specified. In addition to the scheme of treatment Captain McKendrick commenced to train a staff of men for the purpose of investigating the mosquito conditions of the City. His intention was that these men would be subsequently employed as supervisors of anti-mosquito gangs for work in the rains. To meet the cost of the staff necessary for these different duties and the supply of quinine required, a special budget grant of Rs. 12,000 was made by the Corporation.

260. In May 1909 Captain McKendrick, I. M. S., was recalled to duty at the Pasteur Institute of Coonoor.

261. In June 1909 the Officer appointed to succeed him was requested by the members of the Malaria Investigation Committee to report at a very early date what other immediate action, in his opinion, should be taken by the Municipality and the different public bodies represented on the Committee to mitigate the prevalence of malaria. The memoranda reproduced below were therefore drawn up and submitted to the respective members of the Committee on July 17th, 1909.

262. At the time when these memoranda were submitted the investigation of mosquito breeding places was incomplete, but very large numbers of *Neocellia stephensi* had been found breeding in the enclosure of the New Dock Works, in the neighbouring compounds belonging to the Railway Companies, etc., and in some hundreds of house-wells in the North Fort. Experimental mosquito destruction had also been undertaken in the New Dock enclosure for a period of some weeks after the onset of the rains; and it had been found that an Assistant Surgeon and six to ten men could keep that area practically free from mosquito larvæ by the use of larvacides.

263. The memoranda submitted to the members of the Malaria Investigation Committee were as follows:—

Letter No. 114, dated 17th July 1909, from Dr. Charles A. Bentley, M.P., D.P.H., on Special Duty, Malaria Investigation Committee, Bombay, to the Municipal Commissioner for the City of Bombay.

"In accordance with the minutes of the Committee Meeting held on "June 30th, 1909, I have the honour to submit for your consideration,

"the enclosed Memorandum dealing with Malaria in Bombay with especial "reference to the steps which in my opinion should be undertaken by the "Municipality with a view to mitigating the disease during the present "season and eventually attempting its complete control.

Memorandum.

"The Investigation into the distribution of Malaria within the City of "Bombay has shown the disease to be prevalent over a very large area. "In particular it appears to be present in a persistent form in—

"Ward A.—Lower Colaba and Middle Colaba.
South Fort.
North Fort.
Esplanade.

"Ward B.—Mandvi.
Chakla.
Umarkhadi.
Dongri.

"Ward C.—Market.
Dhobi Talao.
Fanaswadi.
Bhuleshwar.
Khara Talao.

"Ward D.—Walkeshwar (and to a less extent Chaupati).
Girgaum.

"Ward E.—Tardeo.
2nd Nagpada.
Byculla.
Tarwadi.
Mazagon.

"It may be observed that it thus affects the most densely populated "portion of the City involving an area with a population of over 650,000 "people. It is not suggested that other parts of the Island are Malaria "free, for this is very far from being the case and there is evidence to "show that cases of Malaria occur in practically every part of Bombay "during certain times of the year, but it may be broadly stated that, in "the abovementioned areas Malaria exists to such an extent as to give "indications of its presence throughout the year. The incidence of Malaria "is especially marked along the whole of the east coast of the Island "between Kasara Basin, Mazagon, and the Sassoon Dock, Colaba, but it is "also prevalent in the west coast where a centre occurs in Walkeshwar "in an area below the Malabar Hill Reservoir. Broadly speaking, severe "Malaria may be said to exist over an area including—

Mazagon—south of Gunpowder Road.
Tarwadi—south of Nesbit Road.
Dongri.
Umarkhadi.
Khara Talao.
Mandvi.
Chakla.
Market.
Dhobi Talao.
Esplanade.
North Fort.
South Fort.
Lower Colaba.
Portions of Walkeshwar.

"The population of this area numbers over 375,000 persons or very "nearly two-fifths of that resident upon the whole Island of Bombay, and "out of this population the proportion actually suffering from Malaria must "be very large.

"A recent miscroscopical examination made by myself of specimens "of blood taken from nearly 700 residents in North Fort and Esplanade "Sections, a portion of the intensely malarious area, has shown that 35 per "cent. to over 50 per cent. of the adults are infected with Malaria "parasites, while among children the rate may be even higher. In one "instance in a mixed community of adults and children the examination "of 63 (46 adults and 17 children) showed that no less than 44 or nearly "70 per cent. were harbouring the infection. A statement showing the "admissions for Malaria among some 1,882 Bombay Police during 1908, "kindly supplied to me by Dr. Powell, throws further light upon the "morbidity caused by Malaria in Bombay.

"Statement showing proportion of admission for fever from each district "in the City of Bombay from 1st May 1908 to 31st April 1909 :—

	No. of Police.	No. of Admissions.	Admission per thousand.
*Fort	325	440	1,353·9
*Dockyard	81	267	3,296·3
*Mandvi	71	140.	1,818·1
*Chakla	63	56	888·8
*Umarkhadi	70	38	542·8
*Dongri	45	29	644·4
*Market	72	51	708·3
*Dhobi Talao	81	102	1,259·2
Bhuleshwar	69	24	326·2
Null Bazar	76	22	289 4
Girgaum	33	22	666·6
*Walkeshwar	55	46	836·3
Mahaluxmi	45	17	377·7
Kandewadi	72	32	444·4
*Mazagon	51	56	1,098
Tarwadi	68	27	397
Kamatipura	53	15	283
Nagpada	33	7	212·12
Jacob Circle	43	21	488·4
Parel	54	36	666·6
Matunga	55	29	527·27
Mahim	81	23	296·3
Worli	72	19	263·8
*Water Police	96	110	1,145·8
*Prince's Dock	112	311	2,776·8
Total ...	1,882	1,941	1,031·3

* 1,128—1459·2 per 1,000. This refers to Police engaged in the specially malarious areas.

N.B.—Office, Detective, Armed and Mounted Police are omitted owing to their residence being scattered.

"These observations serve to give some idea of the amount of sickness "produced by this disease within the City. As to the financial loss "resulting directly and indirectly from this cause, no estimate can be "given, but there is little question that it must amount to many lakhs "of rupees annually. Such loss is necessarily very greatly increased when "Malaria becomes epidemic as is has done in Bombay recently. But it "must not be supposed that the disease was not present in considerable "amount within the City previously. Enquiry shows that it has existed "in certain parts of Bombay for many years and there is no likelihood "of its dying out spontaneously. On the other hand there appear to be "grave reasons for believing that in the absence of organized measures for "its suppression, the disease will persist, and may even extend and increase "in intensity in certain localities from time to time; while so long as it "remains unchecked, the City will be exposed to the danger of epidemics "similar to the one which has been witnessed during 1907-08. Malaria "presents in Bombay certain peculiarities both as regards distribution "and propagation which are in marked contrast to generally recorded "observations in other parts of India. In this City, Malaria, which is "generally considered to be a disease of scattered rural districts and "tracts of jungle and unopened country, may be found widely distributed "through densely populated areas, such as Chakla, Umarkhadi and "Khara Talao with populations of from 500 to over 600 persons per "acre. The explanation of this fact is given by a study of the habits "of the mosquito which serves as the common carrier of the infection in "this City. For the species of Anopheles—*N. stephensi* which serves to "propagate Malaria within Bombay, is found to breed readily in wells, "cisterns, tanks, tubs and in fact in almost any conceivable receptacle for "water—natural or artificial—whereas in many places where other varieties "of Anopheles are concerned—only natural breeding places such as

" streams, ponds, ditches and puddles are dangerous. These facts have a " considerable bearing upon the problem of Malaria prevention in Bombay. " It appears to me that organized and systematic mosquito destruction " will afford a means of controlling the disease within definite limits, and " provided it is carried out with due care, should reduce the liability to " epidemic manifestations or even entirely prevent their occurrence. It " must not be supposed that the task of mosquito destruction to an extent " sufficient to actually control Malaria, will be an easy one. But given a " proper staff and organization, adequate powers, and sufficient expenditure " and I believe it will be quite possible to obtain the desired results. " I wish to make it clear from the outset that in my opinion in order to " deal with the matter effectively it will be necessary to create a Special " Department engaged solely in mosquito destruction, and working under " the control of the Executive Health Officer. Such a Department must " be a permanent one and must possess a small regular staff of skilled men " whose sole duty all the year round must be anti-mosquito work. In " addition, arrangements must be made for increasing the staff by the " addition of unskilled men during the period between the outset of the " rains and the complete establishment of the dry season. In this short " memorandum it is impossible to go into details, which will require " careful discussion. But I would suggest as a tentative measure that " steps be taken to organize such a Department for immediate work in " Wards A. and B. and possibly Walkeshwar with a view to subsequently " extending operations over the whole southern portion of the City south " of a line drawn between Kasara Basin, Mazagon, and Mahaluxmi Battery, " and possibly in other parts of the Island. Briefly, I would suggest that " the area in which operations are to be commenced should be divided into " sections, of a size to allow of each being inspected thoroughly by a " responsible officer at weekly intervals. Each one of these sections must " be sub-divided and put in charge of a trained mucoadum who must " control one to three or four men. Large sized plans must be prepared of " each section and sub-section, wherein all possible breeding places must " be plainly marked and every place in which mosquito larvæ have been " found must be indicated. In addition, section and sub-section registers " must be drawn up of every potential breeding place for mosquitoes and " a diary or journal must be kept by each Inspector recording his visit to " each sub-section and the result of his inspection. The whole staff must be " made clearly to understand that their sole duty is to prevent mosquitoes " breeding within the area under their charge. Reports must be made at " stated intervals to the Executive Health Officer or the Officer specially " deputed to control the Department. Failure to prevent the breeding " of mosquitoes must be at once reported to head-quarters. Failure to " prevent mosquitoes breeding or to report such failure and its reason " should entail liability to dismissal. It will be clear that the areas under " the control of each Inspector must not be made too large or there will be " inadequate supervision which will result in certain failure. Further it " must be pointed out that the whole question of mosquito destruction in " a City such as Bombay presents a problem for the solution of which little " assistance can be gained from examples of such work elsewhere. General " principles only can be laid down to guide us in framing a workable " scheme, and actual experiment in a limited area must be undertaken to " determine the minimum staff necessary, the powers of control required " and the probable expenditure that will be involved in order to attain " success. It is for these reasons that I suggest that steps should be taken " for the organization of a Special Department to work in a limited area in " A. and B. Wards in connection with similar work to be carried out by " the Port Trust and Railway Authorities. We must not lose sight of the " fact that mosquito destruction must be carried on indefinitely, although " there is little question but that it will become easier year by year. " In this connexion it must be mentioned that the question of wells, " public and private, has a special importance. In the North Fort, at " Mazagon and at Colaba unguarded wells form the breeding places of large " numbers of *N. stephensi* and unless adequate control of wells can be

"ensured it will be impossible to effectually carry out any measure of "mosquito destruction with hope of success. I am preparing a special "report dealing with this question which I shall forward separately."

264. **Letter No. 116, dated the 17th July 1909, from Dr. Charles A. Bentley, M.B., D.P.H., on Special Duty, Malaria Investigation Committee, Bombay, to the Municipal Commissioner for the City of Bombay, re State of Wells, private and public, within the area of Fort North.**

"In accordance with the minutes of the Committee Meeting held on "the 30th June 1909, I have the honour to draw your attention to the "dangerous state of the wells, private and public, within the area of the "Fort North. A careful examination has been made of *511* wells within "this section with the following result:—

(1) 240 have been found to contain very numerous larvæ of Anopheles Mosquitoes.

(2) 32 of these contain larvæ of Culex or Stegomyia in addition.

(3) A total of 83 wells have been found to contain larvæ of either Culex or Stegomyia Mosquitoes.

"It is stated by a large proportion of house-holders that many of "these wells are unused. In a few cases wells have been discovered whose "existence was unknown to the present occupiers of the houses in which "they were situated. Many occupants of houses with mosquito-infected "wells complained of being troubled with mosquitoes, but few, if any, "appeared to know that the source of their trouble was the open or "improperly guarded well in the house itself. A certain proportion of "wells are provided with wooden covers, but many of such covers are "useless and in other cases there is evidence that they are frequently "left open. A few wells have been found blocked up and in certain cases, "particularly in the neighbourhood of Frere Road, wells have been treated "recently with Pesterine and are free from mosquito larvæ.

"*Species of Mosquitoes breeding in the Wells.*—Among the 240 wells "infested by the larvæ of Anopheles, nearly every one is found to "be the breeding place of *N. stephensi*, a most dangerous carrier of "Malaria. The few exceptions show the presence of *M. rossi*. It "has been shown experimentally that this species of Anopheles can be "readily infected with Filaria, and in all probability it is one of the agents "in the propagation of Filarial Disease. In the course of the present "investigation adult mosquitoes of this species, that have been caught and "examined in order to test the possibility of their serving as carriers of "Malaria, have been found to be very heavily infected with Filarial "embryos. In this connection it may be remarked that certain common "species of Culex mosquito are known to be also concerned in the "transmission of Filarial disease, and among the 83 wells which contain "other than Anopheles larvæ Culex mosquitoes of this kind are to be "found breeding. A certain proportion of the wells contain the larvæ "of *Stegomyia calopus* (formerly known as *Stegomyia fasciata*), the "species of mosquito concerned in the propagation of Yellow Fever in the "Western Hemisphere.

"*Malaria in the Fort.*—Enquiry shows that Malaria has been present "in the North Fort Section for many years, and a reference to past "history reveals the fact that for generations this portion of the City "has suffered from the evil effects of 'dangerous miasmata.' It is certain "that Anopheles mosquitoes must have existed in this part of Bombay "for a very long time and it is probable that their distribution has been "extended from time to time. For mosquitoes can be conveyed long "distances in covered vehicles, etc., and they may frequently be found "taking shelter in shigrams and the hoods of victorias. It appears "probable that among the many carriages of all kinds which daily visit "and sometimes remain for hours within the busy trading centre of "Fort North, a large proportion carry away mosquitoes from the locality

"and in this way serve to transit them to other parts of the City. "Dangerous mosquitoes of the same species as those breeding in such "large numbers in the wells of the Fort can be found at Malabar "Hill and in wells at Mazagon and Colaba, and exist in smaller numbers "in many other parts of Bombay. It is certain that so long as such "large numbers are permitted to breed unchecked within the wells of "the Fort many of them will be carried thence to other localities and from "time to time new centres of infection will thus be set up in places at "present but little affected. It appears probable that such an extension of "the distribution of dangerous Anopheles Mosquitoes has been going on for "very many years within Bombay, and that this condition of things has "been one of the primary causes at work in bringing about the increased "prevalence of Malaria which culminated in the recent epidemic mani- "festation of the disease. At the present time Malaria is rife within the "Fort, especially the North Section which contains so many wells. A "recent examination of 2,782 children resident in this locality revealed "the fact that 40·9 per cent. were suffering from enlarged spleen.. This "compares very unfavourably with the result of an examination of "2,761 children in Wards F. and G. among whom only 1·4 per cent. "showed splenic enlargement. A more recent microscopical examination "of the blood of 170 persons resident in Fort North showed no less than "77 to be infected with Malaria parasites. The people examined included "57 adults and 113 children. Of the adults 28 were infected and of "the children 49. Among the children a considerable number had "been undergoing quinine treatment or the proportion of infections would "undoubtedly have been much higher. It may be mentioned that for the "purposes of this examination no selection of cases was made, blood films "being taken from any persons who were willing. These observations "show that the present sanitary condition of North Fort, especially as "regards the existence of such an extraordinary number of unguarded "wells, is a menace to the health of the whole City. For the danger "resulting from the continuous breeding of such large number of "mosquitoes is not confined to residents in that locality only. There are "many wells in other parts of the City at present free from mosquitoes; but "sooner or later they will become infected if dangerous centres such as "those in the North Fort are permitted to remain unchecked, and so "long as this is case the the whole City must necessarily be exposed to "the danger of recrudescences of epidemic Malaria. In my opinion there "should be no delay in taking adequate steps to control this danger. "All unused wells should be filled in as soon as possible. Those that "are required for use should be provided with permanent covers suitably "designed and arrangements made for raising the water by means of a "hand pump. The depth of no well that I have seen would preclude the "use of a simple suction pump. It is probable that the most suitable "form of covering would be a permanent cover of re-inforced concrete. "The cost of protecting these wells efficiently need not be great, while "the benefit to the health of the residents in the locality will be enormous. "Moreover a constant source of danger to the whole of the City will "have been removed. It must be remarked that it will not be sufficient "to protect the wells in which larvæ are at present breeding. There "are probably millions of adult mosquitoes already existing in the Fort "and as soon as their favourite breeding places are abolished, numbers of "these will seek other suitable locations. This being the case it will "certainly follow that any well in the neighbourhood to which they can "obtain access, if not already infected, will speedily become so. In "addition it is more than likely that a far larger proportion of wells "actually harbour mosquito larvæ than has been shown in the course "of the present enquiry, for unless they are present in very large "numbers it is exceedingly difficult to dip them out with either a bucket "or a net, and in many cases the water can be reached in no other way. "In my opinion a well which serves as a breeding place of mosquitoes "should be declared a *dangerous nuisance* and a house which contains

"a well in which Anopheles mosquitoes are allowed to breed should be "declared *unfit for habitation.* In conclusion I beg to point out that it is "my belief that until steps have been taken to remedy the condition of "the wells in Fort North, all other forms of anti-malarial sanitation within "this area will be rendered futile and moreover the continued existence "of numerous uncontrolled breeding places of Anopheles in this locality "will tend to annul efforts at mosquito destruction in adjoining areas."

265. *Action taken by the Municipality.*—On the receipt of these memoranda the following action was taken by the Municipality.

After being submitted to the Municipal Corporation they were considered by a Special Committee in consultation with the Municipal Commissioner and the Executive Health Officer, and the latter officer was asked to report on them. He advised against the creation of a Special Department and recommended instead the appointment of a small staff divided into a different number of gangs, one or more to be allocated to each ward in the City. These gangs were to be engaged solely in anti-mosquito work and were to supplement the work of this kind already supposed to be done by the ordinary sanitary staff; and they were to undertake the destruction of mosquitoes of every kind.

266. The proposal of the Health Officer was accepted by the Corporation and a special staff of 10 Sub-Inspectors at Rs. 40 each per mensem and 10 gangs of 5 coolies each at Rs. 11-1-3 per man per mensem was appointed. The yearly cost of these gangs was estimated at Rs. 12,000. The staff was a temporary one and was at first appointed for only six months from October 1909. Subsequently they were again appointed for another year. Originally the idea was to distribute this special staff over the whole of the island, but finally they were allocated to A., B., D. and E. Wards, an area covering 8·6 square miles, and possessing a population of 522,000 people housed in 23,469 houses. Though appointed primarily for anti-malaria work they were directed to undertake measures against every kind of mosquito. The special staff commenced work on October 1st, 1909, just before the end of the monsoon.

267. It will be seen that the proposals accepted by the Corporation were on the same lines as those originally adopted in 1902, when 3 Sub-Inspectors and 12 men were appointed to carry out general anti-mosquito work in area of 3·8 square miles among a population of 376,642 and again in September 1908 when 4 Sub-Inspectors with 4 men each were deputed for anti-mosquito work in A., B., D. and E. Wards. The scheme of work embodied a considerable departure from the suggestions submitted in the memorandum to the Municipal Corporation, more especially as regards the sphere of operations. In the memoandum it had been suggested that work should be commenced in *a limited area in A. and B. Wards* in connexion with the similar work to be carried out by the Port Trust and Railway Authorities mainly with a view to determine the minimum staff required, the powers of control necessary, and the probable expenditure that would be incurred for efficient work; moreover the area referred to included a part of the City which had been shown to be seriously affected by malaria and systematic investigation of mosquito breeding places had already been conducted there; but very little was known regarding the real condition of things in other parts in the Island.

268. The memorandum submitted to the Improvement Trust was as follows:—

Letter No. 115, dated the 17th July 1909, from Dr. Charles A. Bentley, M.B., D.P.H., on Special Duty, Malaria Investigation Committee, Bombay, to the Chairman, Bombay Improvement Trust.

"The enclosed copy of a memorandum that has been forwarded "to the Municipal Commissioner will serve to indicate the lines upon "which it is suggested anti-malarial sanitation should be initiated in "Bombay. The Improvement Trust controls many areas within the "City—several of which lie within the specially malarious zone. In

"particular the Paltan Road Chawl area is the site of intense malaria "and in the Dongri Koli area adjoining, many actual and potential "breeding places for Anopheles (*N. stephensi* and *M. rossi*) have "been found from time to time. In my opinion it will be necessary "to undertake work in these areas of a similar nature to that which "it has been suggested shall be initiated by the Municipality, the Port "Trust and the Railway Companies. It appears to me probable that one "trained man assisted by an ordinary coolie could ensure that the "Improvement Trust areas referred to are kept free from mosquito larvæ "during the monsoon and one man alone could do the work in the "dry weather. But the question of supervision is in my opinion all "important, and it would be necessary that the work of such a staff should "be inspected weekly by some responsible officer engaged on this kind of "work alone. I do not feel that it lies within my province to suggest "what arrangement to this end should be made by the Improvement "Trust. I have suggested to the Port Trust and Railway Companies that "it would be advisable to appoint responsible Inspectors, and it appears "to me that trustworthy time-expired European soldiers with a good "knowledge of the vernacular would be the best type of men to employ. "But in the case of the Improvement Trust no single area is sufficiently "large to require one such men and though possibly one Inspector could "superintend the work on the whole of their property it is possible that it "would be better that each separate Improvement Trust area should be "under the supervision of the special municipal inspector for the anti-"mosquito work of the section in which it lies."

269. *Action taken by the City of Bombay Improvement Trust.*—The Improvement Trust did not appoint a special staff, but they deputed one of their subordinate officers to pay special attention to the question of mosquito breeding places on their Estates. For the purpose of training this officer and other Inspectors of the Trust's Estates, demonstrations were given by the Special Officer and staff employed on the malaria investigation.

In the Admistration Report of the Improvement Trust for 1909-1910 the following paragraph appears:—

"A new departure in 1909-1910 was the training of all inspectors "and peons on the Trust Estates to find out mosquito breeding places "and destroy larvæ. Systematic arrangements were made for the "periodical inspection of all wells, tanks and cisterns in Trust Estates in "co-operation with the lessees, and the result has been the elimination of "many mosquito breeding places and a great reduction in the mosquito "pest. Cisterns on Trust Estates are now required to be made with "close fitting covers so that mosquitoes cannot breed in them. The "expenditure on this anti-malaria campaign in 1909-1910 was Rs. 365."

270. The memorandum submitted to the Port Trust is given below:—

Letter No. 117, dated the 17th July 1909, from Dr. Charles A. Bentley, M.B., D.P.H., on Special Duty, Malaria Investigation Committee, Bombay, to the Superintendent, P. & O. Company, one of the Port Trustees.

"In accordance with the minutes of the Committee Meeting held on "the 30th June 1909, I have the honour to report as follows. The present "enquiry into Malaria in Bombay has shown that the disease is especially "prevalent along the whole of the east coast of the Island between the "Kasara Basin, Mazagaon and the Sassoon Dock, Colaba. This tract "includes large areas under the control of the Port Trust. Investigation "has shown that an area of very intense malaria exists in and around "Princes and Victoria Dockyards. (In 1903 the admissions for malaria "among the police stationed at these docks stood at 2776·8 per 1,000 against "an average of 1031·3 per 1,000 for the whole of Bombay.) In particular "the enclosure of the New Dock Works can be shown to be the site of "very severe malaria and probably the centre from which the disease is "disseminated to a considerable area around. An examination of the Prince's

"and Victoria Docks, Carnac Bunder and areas north of the Port Trust "Dispensary between Manson and Frere Roads, has shown the existence of "numerous potential breeding places for mosquitoes. In some cases larvæ "of *Anopheles stephensi* have been found recently, and I have been "informed that they were prevalent in many places within this area during "last monsoon. But such potential breeding places, numerous as they "appear to be, and requiring the most careful attention and control, sink "into insignificance beside the condition of things prevalent within the "New Dock enclosure. Within this area, especially upon the land occupied "by the stone heaps, etc, lying between the Frere Road and the New Dock "wall, there are countless puddles and pools of water formed by the recent "heavy rain. It is quite impossible to give even a partial estimate of the "number or area of such breeding places as already exist, but it may be "stated that practically every shallow collection of water on the upper "level of the works, except such as have been treated with Pesterine, "contain numerous larvæ of anopheles—90 per cent. of which are those "of *N. stephensi*. At the present time it appears to me probable that "there are more mosquitoes of this variety breeding within the New "Dock area than in the whole of the other parts of Wards A. and B. put "together, excluding perhaps Fort North section with its innumerable "wells. A recent examination of the blood of 63 persons resident within "the New Dock enclosure has shown that, out of the 46 adults and 17 "children from whom the blood was taken, 44 or nearly 70 per cent. har- "boured malaria parasites. This is the highest proportion yet found in "any community in Bombay. These observations serve to show that it is "necessary to adopt organized and systematic measures for the control "and suppression of anopheles breeding grounds if the incidence of "malaria is to be diminished within this area and the neighbourhood. "The question is of such immense importance to the City and Port of "Bombay that in my opinion the measures to be adopted should be "as follows.

"*For New Dock Enclosure.—A whole time* European Inspector should "be appointed whose sole duty must be the supervision of anti-mosquito "work. It is quite impossible for a man to properly control the innumer- "able breeding places which already exist if he has other duties to perform "in addition. The responsible officer should have a sufficient staff at his "disposal including men trained to find mosquito larvæ. It is probable "that many of the small pools could be easily drained or levelled, but others "must be systematically treated with Pesterine or crude petroleum. For "this purpose suitable sprayers must be provided—preferably of the knapsack "type. The Success Sprayer made by the Deeming Manufacturing Com- "pany of Salem, U. S. A., gives satisfactory results. The inspector must "systematically patrol the whole area, carefully examining each likely "breeding place, assisted by trained men. (The services of trained men "can be obtained by application to the Municipal Commissioner who "has the names of *nine* such men who are available for immediate "employment.) It is essential that whoever be appointed to superintend "such work must be made clearly to understand that his *sole* responsi- "bility is the prevention of mosquitoes breeding in the area within "his control. Failure to carry out such work should entail liability "to dismissal.

"*Quinine distribution.*—In addition to mosquito destruction I think "it will be necessary to employ a compounder to distribute quinine in a "palatable form (sugar-coated tablets) daily from house to house, among "the residents within the Dock enclosure. Already there is a very large "amount of malaria present among these people and situated as they are in "the immediate neighbourhood of numberless Anopheles breeding grounds, "they are a menace to the health of the shipping and the population "in the City.

"*For Old Dock Area.*—In regard to the Old Dock Area, I consider "that as there are so many potential breeding grounds within this area it is

"necessary to employ a full time inspector for anti-mosquito work there "also. He should be responsible for the area from Wari Bunder to the "New Dock and should have a sufficient staff at his disposal with one or "more men trained to find mosquito larvæ. As the work must necessarily "be carried on from year to year special plans of the areas to be dealt with "should be prepared and a record of potential breeding places should be "made as well as that of places in which larvæ are discovered from time "to time. A daily dairy or journal should be kept by the inspector who "should be clearly made to understand that his sole responsibility is the "preventing of mosquitoes breeding within the area under his charge. "Failure or neglect of this duty should entail liability to dismissal. This "is in broad outline a suggested scheme which is I believe the minimum "which will prove successful in mitigating malaria along this portion of "the eastern coast of Bombay. Details can only be arranged after initia- "tion for it is impossible to state the number of men likely to be required "at all times of the year, although during the dry weather, when guard "must still be kept, very few will suffice. In my opinion a responsible "inspector for both the Old and New Dock areas is a *sine-qua-non.* As "soon as such men can be selected I am quite willing to do anything I can "in the way of training them in their duties, and on the occasion of my "visits to the Docks I will inspect and, if necessary, report upon their "work, but it must be understood that they are responsible to the "Medical Officer of the Port Trust, the Executive Health Officer of the "Municpality, or some other competent authority to be subsequently "determined, and weekly reports regarding their work should be submitted "to such an authority."

271. *The action taken by the Bombay Port Trust.*—The Bombay Port Trust appointed two European Inspectors at salaries at about Rs. 150 each per month, engaged six of the men who had been trained under Captain McKendrick's scheme, and also employed a certain number of untrained coolies to work with them. One inspector was deputed to work in the New Dock enclosure and the immediate neighbourhood and the other on the Princes and Victoria Docks and the Port Trust Estate to the north of them. A supply of sprayers, kerosine oil, pesterine (crude petroleum) and phenyle was also provided. The European Inspectors were sent to receive instructions under officers of the Health Department for a short time before undertaking their duties, and arrangements were made for the general supervision of the work by certain of the Deputy Health Officers. In 1909 the Port Trust also commenced the distribution of quinine amongst their employees. The Port Trust expended Rs. 2,712 on anti-malaria work in 1909 and Rs. 7,248 in 1910.

272. The memorandum submitted to the G. I. P. Railway Company was as follows:—

Letter No. 118, dated the 17th July 1909, from Dr. Charles A. Bentley, M.B., D.P.H., on Special Duty, Malaria Investigation Committee, Bombay, to the General Traffic Manager, G. I. P. Railway Company.

"In accordance with the minutes of the Committee Meeting held on "the 30th June 1909, I have the honour to report as follows.

"In the course of the present enquiry it has been shown that the "incidence of malarial disease among the general population is greatest in "the Wards A. and B.

"The Victoria Terminus with its compound and sidings and the Bori "Bunder and Wadi Bunder goods yards and sidings lie within this area of "marked malarial intensity, and investigation has shown that—

(1) Numerous potential breeding places for mosquitoes exist within these enclosures.

(2) Larvæ of *N. stephensi* (the most important malaria carrying anopheles in Bombay) have already been found in certain places in these areas.

(3) Examination of children living within these compounds has given evidence of nearly universal malarial infection.

"In view of these facts it would appear advisable to take immediate steps—

(*a*) to provide covers to any open wells, cisterns or tanks within these areas;

(*b*) to drain or fill up depressions in which puddles or pools of water may lie, affording opportunities for the breeding of mosquitoes;

(*c*) to destroy the larvæ of mosquitoes which may be found breeding in places that cannot be permanently protected or obliterated.

"In order that such work may be carried out with certainty and "especially for the systematic destruction of mosquito larvæ, it will be "necessary to appoint men who have sufficient knowledge of mosquitoes "and the places where they may be found breeding. Indians may easily "be trained for such work and in fact the services of men who possess such "knowledge can be secured by application to the Municipal Commissioner "who has been furnished with the names of nine men who have received "training in seeking for mosquito larvæ and who are available for immedi- "ate employment. It is probable that at least one such man will be "required for Victoria Terminus and Bori Bunder goods yard and another "for Wadi Bunder. I have not yet had time to investigate the condition "of affairs at the G. I. P. Workshops and Mazagon Station, but as both "these Yards are within the malaria-affected zone it is probable that anti- "mosquito work will be required there also. I shall hope to inspect these "places at an early date In addition to the men referred to it will be "necessary to associate with them at least one other man at each yard to "assist in the work of mosquito destruction. A sufficient supply of Peste- "rine or crude kerosine must be provided, and a sprayer of the knapsack "type filled with a suitable nozzle will be required. The ordinary method "of applying Pesterine as practised in Bombay is both wasteful and "inefficient. Lastly, as such work must be carried on with regularity year "after year through each monsoon and in lessened amount even through "the dry season, at least for several years, it will be necessary to make "arrangements for proper and adequate supervision by a responsible man "whose sole duty this must be. Lack of supervision will mean failure and "a mere waste of money, and any suggestion to arrange for such work to be "done in addition to other duties, indicates a failure to appreciate the real "importance of the question. It is probable that work of this kind will be "carried out most efficiently by a European such as a trust-worthy time- "expired soldier with a good knowledge of the vernacular. One such man "could supervise mosquito destruction on the railway property from "Victoria Terminus to the Mazagaon Station. It would be quite possible "to train such a man in his duties in a very short time and arrangements "might be made for him to jointly superintend the B. B. & C. I. goods "yard, as well as the G. I. P. Railway property. Further in order that "mosquito destruction may be carried out systematically from year to year "it will be necessary to prepare large sized plans of the railway stations, "compounds and yards and to indicate upon such plans the situations in "which mosquitoes have been discovered to breed. A proper register of "such places must likewise be prepared while a dairy or journal must be "kept by the inspector in which full particulars must be recorded as to the "finding of larvæ, the teratment and the result. It is all important that "whoever is appointed to undertake such work should be made clearly to "understand that his duties consist solely in seeing that no mosquitoes are "allowed to breed anywhere within the area under his control and any "neglect of this responsibility should render him liable to dismissal. The "relation between such a proposed staff and any similar organization initi- "ated by the Municipality must be determined subsequently. It may be "pointed out in conclusion that the existence of breeding places for danger-

"ous varieties of Anopheles in or near the railway stations and yards is a "grave danger, for mosquitoes are frequently carried from one place to "another in railway carriages and covered waggons, etc., and in this way "malaria may be disseminated from one locality over a wide area."

273. A memorandum similar to the one addressed to the representative of the G. I. P. Railway Company was submitted to the representative of the B. B. & C. I. Railway Company also.

274. *Action taken by the G. I. P. and B. B. & C. I. Railway Companies.*— The G. I. P. Railway Company appointed a European Inspector on Rs. 150 per mensem and a small staff of trained men for work in their yards. The cost of the special anti-malaria work carried out by them amounted to Rs. 747 in 1909 and Rs. 1,416 in 1910. The B. B. & C. I. Railway Company appointed two trained men to work in their yards and subsequently by a joint arrangement with the G. I. P. Railway Company the European Inspector engaged by the former Company was made responsible for the carrying out of the work in their yards also. The B. B. & C. I. Railway Company also expended a considerable amount in distributing sugar-coated quinine tablets to their employees during 1909. The tolal expenditure on anti-malaria work during 1909 and 1910 amounted to Rs. 643.

275. In certain parts of the city preventive work of the similar nature was undertaken. At the request of the Director of the Government Dockyard several inspections were made of the premises there by the staff engaged in the malaria investigation. The residents in these premises had suffered severely from the presence of mosquitoes in 1908, and in 1909 a considerable amount of malarial infection was found among the native servants there. Much good as far as reducing the number of mosquitoes had been effected towards the end of 1908 owing to the measures adopted by the Director; but larvæ of *Neocellia stephensi* were found breeding in a number of open tanks by Captain McKendrick and again after his departure in a few other places. A mosquito searcher was supplied to the Dockyard from among the men trained during the enquiry, and his services were entertained for a short time until certain of the Dockyard subordinates were sufficiently experienced to continue the work.

276. During 1909 the P. & O. Company decided to institute a system of quinine parades among the crews of all their vessels entering the port. Many of their crews had suffered severely from malaria in 1908; but in 1909, 25,000 quinine pills were distributed amongst them, and very few of them were affected by the disease. The Company also deputed one of their subordinate staff to inspect their private dockyard, workshops and quarters, where mosquitoes had been found breeding in a number of places. The mosquitoes present were chiefly *Stegomyia* and *Culex fatigans*, but *Neocellia stephensi* were found breeding in a few water cisterns, and necessary measures were taken against them.

277. Meanwhile the distribution of quinine commenced by Captain McKendrick had been continued, but it was decided to extend the distribution to as large a proportion as possible of the poorer population in the most seriously affected localities, instead of confining it merely to young children suffering from enlarged spleen. Many adults in these areas had been found infected with malaria and children not exhibiting palpable splenic enlargement also showed the presence of numerous parasites on blood examination. The modification of the scheme of quinine treatment made it necessary to confine the distribution to a smaller area than before, and as anti-mosquito work was being commenced by the Port Trust and Railway Companies on a considerable scale, it was decided to limit quinine distribution to an area round the New Docks. The distribution of quinine was therefore stopped in the North Fort, with the exception of the portion adjoining the New Dock Works. It was felt that, in areas like the North Fort, where the presence of severe malaria was so obviously due to the existence of large numbers of anopheline infested wells, the distribution of quinine was likely to postpone the carrying out of the proper and more radical measures, the protection of these wells; whereas in the area finally selected for treatment it was quite beyond

the power of the local residents to greatly improve their condition, and the distribution of quinine amongst them, co-incidently with the adoption of anti-mosquito measures, would probably effect some mitigation of the disease. Quinine distribution was therefore pressed with vigour in the Frere Road, Paltan Road and parts of Mandvi and Chakla and by the middle of August about 4,000 people were under treatment.

Section 3. 278. *AD INTERIM* REPORT OF 1910.—During 1909 considerable progress was made in the investigation of malaria in the south of Bombay Island, and as it appeared wise to publish as soon as possible a brief summary of the information obtained so that it might serve as a guide to the work of malaria prevention that was already in progress and give some indication of the line of future action, a short *ad interim* report was issued early in 1910.

279. In that report the necessity for obtaining necessary legal powers was emphasized and a scheme of prevention was outlined. A short summary of the scheme recommended is given below :—

"*Measures for the control of Malaria recommended in ad interim* "*report.*—(*a*) The measures required in Bombay for the control of "malaria by the reduction of the mosquito host are best discussed "under two heads—

(1) General.

(2) Special.

"(*b*) As has already been pointed out permanent breeding places of "*Neocellia stephensi* appear to have a special importance, as they enable "the mosquito to continue breeding uninterruptedly all the year round "and form the centres from which temporary breeding places become "infected. This being so, the first step in obtaining control of malaria "must be directed towards abolishing all permanent breeding places or "protecting them in such a manner that the malaria-carrying mosquito "cannot make use of them for breeding.

"(*c*) In the survey of mosquito-breeding places it has been shewn "that the commonest permanent breeding places of malaria-carrying "mosquitoes are :—

"(1) Open wells.

"(2) Open and improperly closed house and latrine cisterns.

"(3) Garden and other tanks, fountains and garden tubs, etc.

"(4) In certain localities special permanent breeding places exist "in the form of tanks, filter-beds, reservoirs and foreshore pools.

"(*d*) *General Measures.*—The first step towards attaining control of "breeding places of a permanent character must be a strict limitation of "their number—no increase of potential breeding places of this nature "must be allowed. At the present time, wells are dug, open or improperly "closed cisterns are erected, fountains and tanks are constructed and "garden and other tubs multiplied without let or hindrance. The danger "of this increase of potential breeding places is very great and it is "essential that the community should be protected from further risk by "stringent regulations, briefly :—

"(1) The construction of new open wells must be strictly "prohibited. Owners of property wishing to obtain a well water-"supply must either construct a well with a permanent concrete cover "or make use of an Abyssinian Tube Pump.*

"(2) The erection of open or improperly closed cisterns must also "be strictly prohibited and all cisterns, whether required for latrine, "house, or business purposes, must be made to conform to a given "standard of safety as regards protection from mosquitoes.

* The cost of an Abyssinian tube and pump is about Rs. 25 only.

"(3) The construction of new fountains and tanks within the "limits of the City should be prohibited.

"(4) The use of garden tanks and tubs should be subject to "regulation and their multiplication should be restricted.

"(*e*) Having taken steps to prevent the increase of potential breeding "places it will be possible to set about the reduction of those already in "existence with some hope of success. Among existing potential breeding "places cisterns are the most easily dealt with, as they are a comparatively "modern innovation. Cisterns at present existing in the City may be "roughly divided into three types—

"(A) Open cisterns.

"(B) Closed cisterns, possessing a manhole or other opening for "which a loose lid or hinged door is provided.

"(C) Cisterns possessing, in addition to a manhole, a raised box "for the accommodation of the ball float and valve. This valve-box is "usually closed by a rough lid which rarely fits properly.

"In the light of our present knowledge the danger of open cisterns is "so great that the erection of any more of this type should be absolutely "prohibited and steps should be taken to have those at present in existence "adequately protected. In the case of cisterns of types B and C it is "essential that all openings should be closed in such a manner that no "mosquito can gain access to them. Manhole or valve-box lids, which "must be well fitted, should be *bolted* down, and on no account must "the supply pipe be taken into the cistern through the manhole. When "the regulation of cisterns has been carried out and the faulty ones "have been corrected, all danger from these sources will have been removed, "and beyond occasional inspection their control can be left in the hands of "the Water Department, whose inspectors should be instructed to report "any irregularity which they may discover.

"(*f*) The question of dealing with open wells, fountains, tanks and "garden tubs is a more difficult one, and it is probable that it may be "simplified somewhat by requiring all owners of such potential breeding "places to register them and if necessary to take out a license.

"(*g*) It is possible that a workable scheme for the control of potential "permanent breeding places may be evolved on the following lines:—

"(1) All owners of open or temporarily closed wells, cisterns, "fountains, tanks, garden tubs, barrels and vessels used for the storing "of water should be required to register the same.

"(2) All collections of water of this nature which may offer "facilities for the breeding of mosquitoes should be licensed and subject "to periodical inspection.

"(3) The license should be renewable yearly.

"(4) The Municipal Commissioner should have the power to close, "cover, remove or fill up any unlicensed collection of water of this "nature after due notice to the owner of the same, and the cost of such "work should be recoverable from the owner.

"(5) No collection of water of this nature which could be shewn "to contain mosquito larvæ should be licensed.

"(6) The license for any collection of water of the above nature "which becomes infected with mosquito larvæ, should be cancelled, "unless after due notice the licensee has taken the necessary measures "for getting rid of the mosquito larvæ and protecting the water in "future, to the complete satisfaction of the proper authorities.

"(7) Permanently covered wells and fountains, which have been "converted into flower beds, should not require a license.

"(*h*) It is probable that the immediate effect of such a scheme once "it were put in operation would be automatically to reduce the number of "potential breeding places that at present exist, for owners of such collections

"of water would not care to pay for a license for wells, fountains and tanks "which they did not use.

"(*i*) When once the permanent breeding places of *Neocellia stephensi* "and other malaria-carrying mosquitoes have been controlled, the danger "of temporary breeding places will be greatly diminished; but it will be "necessary to adopt measures for the control and reduction of the latter "also, for there is evidence to shew that certain localities, notably the "Frere Road area, have suffered seriously in the past, mainly because large "numbers of temporary breeding places have been created there.

"(*j*) Owners of large yards and compounds, open spaces and building "sites should therefore be required to level and drain their property and "keep it free from jungle and undergrowth, so as to reduce as far as "possible the danger from collections of fresh rain water in the monsoon. "If such work were done section by section systematically, commencing "with Ward A., it would soon effect a great improvement.

"(*k*) Other temporary breeding places for malaria-carrying mosquitoes "are neither very common nor important. They will be dealt with under "the head of *Special Measures.*

"(*l*) *Special measures for large Cisterns.*—The question of dealing "with cisterns in general has been already discussed and it has been "suggested that the erection of open cisterns should be prohibited in the "future. Small open cisterns or those which are improperly covered can "easily be dealt with, but there still remains the question of large open "cisterns, such as exist in mills and other places. Fortunately with rare "exceptions these do not appear to be very dangerous, and it would "probably be sufficient to require such as already exist to be registered, "licensed and periodically inspected. If found to be breeding mosquitoes "they could be dealt with just as any other permanent breeding places, by "cancelling the license, etc.

"(*m*) *Special measures for Wells.*—No fact has been more clearly "demonstrated in the course of the present investigation than the direct "relationship that exists in the south of the island between the presence of "open wells and the occurrence of endemic malaria. Where there are "many wells there is much malaria; where there are few wells there is "little malaria, unless other special breeding places exist in large number; "and where there are no wells malaria is usually reduced to a minimum. "The protection of open wells therefore becomes the most important general "measure of anti-malaria sanitation. There are many thousands of open "wells in Bombay and nearly three thousand are to be found in the portion "of the City south of Grant Road. Of these a very large number are the "source of the species of mosquito responsible for the spread of malaria. "Many of these wells have been out of use for years and in many other "cases the water is only required for washing purposes or the watering of "plants. From a few wells water is taken for drinking purposes and from "certain others for religious ceremonials, but at least one-half of the total "number are used for no purpose whatsoever. The owners of these wells "are few in number, and the users of the water do not represent a very "large proportion of the population; but the sufferers from malaria, for "which these wells are reponsible, number many thousands.

"(*n*) Broadly speaking, wells may be divided into two classes:—

"(A) Wells within houses or so situated that they are overlooked "by doors or windows from which tenants in the upper floors can draw "water by means of a rope without descending.

"(B) Wells situated in compounds and gardens at a distance from "dwelling houses.

"Observation appears to shew that generally speaking wells of type A "are more dangerous than those of type B. In particular, open wells "in the basement of houses are specially suitable for the breeding of "*Neocellia stephensi.*

"(*o*) Wells may be protected from mosquitoes in many ways:—

"(1) They can be filled up and permanently closed.

"(2) If the well is required as a water supply a tube-pump* "(Abyssinian Tube) may be placed in the well, which can then be filled "up with gravel and sand as recommended by Koch.

"(3) Wells can be completely covered with stone or brick-work, "reinforced concrete, sheet iron or wood, with no opening, and if "necessary a pump can be used for drawing water.

"(4) Wells may be protected by a cover of stone-work or concrete, "sheet iron, wire gauze or wood, fitted with a trap-door and stocked "with suitable fish.

"(5) In some cases wells stocked with large numbers of small fish, "of a species known to pray upon mosquito larvæ, require no other "measure of protection if they are kept free of weed and floating matter.

"Wells in which water has become obviously foul, putrid and "stinking are no danger from the point of view of malaria, because the "mosquitoes that carry the disease will not breed in putrid water. On the "other hand, these wells often breed enormous number of other mosquitoes. "Wells which become foul either from non-use or from the entrance of "sewage of foul matter should be filled-in or permanently closed.

"(*p*) With a view to prevent malaria, owners of wells should there- "fore be obliged to register them and adopt one of the following "alternatives:—

"(1) Fill up the well.

"(2) Permanently cover the well with concrete, stone or brick- "work or sheet iron, allowing no opening through which a mosquito can "pass, and providing no trap-door, but fixing a pump in position if the "water is required for use.

"(*q*) Or, if unwilling to protect them in this manner, owners of wells "of type A or B should be required to—

"(3) (*a*) take out a license for their wells;

"(*b*) protect it with a well-fitting cover of iron gauze (of not more than 1-16th inch mesh) or sound wooden planking or sheet iron, with or without an accurately fitting trap-door; and in addition

"(*c*) keep the well stocked with a sufficient number of small fish of a species known to destroy mosquito larvæ;

"(*d*) allow the well to be inspected periodically:

"Provided that, in the case of wells of type B situated not less "than 50 feet from a dwelling-house, owners may be allowed to

"(4) (*a*) take out a license for the well;

"(*b*) keep the well stocked with large numbers of suitable fish;

"(*c*) keep the well free from weed and floating matter;

"(*d*) allow the well to be inspected periodically.

"Wells required for religious purposes should be covered either with "wire gauze or plate glass to allow of sunlight penetrating to them, but "they must be liable to inspection, and if necessary be stocked with "fish. Foul wells should *not be licensed*, but the owners should be "compelled to close them up.

"(*r*) *Large Tanks.*—All large tanks should be licensed. They should "be kept free of weed other than *Wolffia arhiza*, and be stocked with "large numbers of fish, or failing this periodically treated with kerosine oil "in amount proportionate to their area. Tanks which continued to "harbour mosquito larvæ in spite of these measures should be filled in.

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* The cost of an Abyssinian tube and pump is only about Rs. 25.

"*Fountains.*—Fountains should be licensed and periodically inspected "and owners should be required to keep them stocked with fish of "a suitable species, or to completely empty them and dry them out at "fixed intervals. Failing this they should be filled up and turned into "flower beds.

"*Garden Tanks.*—Garden tanks should be licensed and either stocked "with a sufficient number of suitable fish or completely emptied and dried "out at fixed intervals. Failing this they should be filled up.

"*Garden Tubs.*—Garden tubs should be licensed. They should not "be fixed or sunk in the earth and they should be provided with a suitable "cover. Failure to keep them free of mosquito larvæ should entail the "cancelling of the license and their removal.

"(*s*) *Breeding Places of special character—Reservoirs, etc.*—The "reservoirs and filter-beds with their cushion-wells at Malábár Hill and "Bhandárwáda (Mazagaon), which have been shewn to be dangerous "permanent breeding places for malaria-carrying mosquitoes, require "special measures of control. At Malábár Hill all the filter-beds and the "reservoirs are roofed over, but many sky-lights, ventilators and doors exist "through which mosquitoes can pass in and out. Every ventilator and "opening in the roof must be protected by galvanized-iron gauze, and if "necessary double doors must be provided to prevent mosquitoes entering "and escaping through the door-ways.

"(*t*) At Bhandárwáda it will probably be necessary to cover the "filter-beds and protect every opening with wire gauze.

"(*u*) *Foreshore Pools.*—Foreshore pools exist at Colaba and Malábár "Hill. For dealing with the foreshore pools at Colaba and Walkeshvar "reclamation will prove effective, and in both cases it is probable that the "value of the reclaimed land would amply repay the cost of the work.

"(*v*) *Breeding Places in the New Dock-works.*—Very large numbers "of temporary breeding places of dangerous anopheles (*N. stephensi*) "were found in the new dock-works during the monsoon, in the form "of surface pools of rain water. The most important breeding places "did not appear to be the actual excavations, but pools on the upper surface "of the works—formed in hollows in the ground. These could mostly be "levelled off or filled up before the onset of the monsoon of 1910 without "unduly interfering with the construction work, and purely destructive "measures by the use of larvacides should not be relied upon except as a "last resource. For pools in the actual excavations the use of larvacides "is the only measure that can be adopted and this must be persevered in "until the completion of the work renders it unnecessary.

Breeding Places in the Railway Yards at Victoria Terminus and Carnac Bandar, Mint, Arsenal, Town Hall, New Post Office, St. George's Hospital, Government Dockyard, etc.

"(*w*) At different times of the year breeding places for malaria-"carrying mosqitoes were discovered on all the above premises. These "yards, in common with other large yards and compounds, require properly "draining and levelling; and until this is done they will probably be a "source of danger.

"(*x*) *Hollows and Undrained Spaces.*—There are many hollows and "open spaces in the north of the island which have little influence upon "malaria and do not require either draining or filling in at present on "that account. But a number of observations have shewn that large "yards and compounds, open spaces and vacant building plots, when

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Note.—The kind of fish specially recommended for wells, tanks and fountains is one locally known as "*Piku.*" It can be obtained at Marol. It may be suggested that the Municipality should make arrangements to place fish of this kind in any well, fountain or tank in which the water is sufficiently pure for these fish to live, on the owner of the same making application. If necessary a nominal charge might be made for the fish. *Anabas scandens* is another fish that may be used for placing in wells and fountains, etc. It is known locally as "*Kazari.*"

"improperly drained and levelled, are a great danger if permanent breeding "places of *Neocellia stephensi* exist in their vicinity; and there are places "of this kind in the very heart of the City which undoubtedly serve to "increase the malaria in their neighbourhood. These places should be "dealt with. But whatever is attempted should be carried through "systematically, section by section, or ward by ward.

"(*y*) *Miscellaneous Breeding Places.*—In certain places, notably in "Frere Road and Manson Road, near Prince's and Victoria Docks and at "Colaba, near the Apollo Press, collections of machinery afford numerous "breeding places for *N. stephensi* during the monsoon. In certain other "places collections of old tins, tubs, etc., provide breeding places for "mosquitoes of all kinds, *N. stephensi*, the malaria-carrier, among them. "At Jamsetjee Bandar in Colaba, earthenware vessels and tubs of dye used "by fishermen for colouring their nets have been found to afford excellent "breeding places for *N. stephensi* and other mosquitoes.

"(*z*) In regard to all such breeding places attempts at preventing "their formation or controlling them will be futile, unless it is clearly "understood that neglect on the part of those responsible will entail a "penalty. Owners of machinery should be compelled to stack it in "such a way that it will not afford opportunities for the breeding of "mosquitoes. Owners of empty tins, etc., should likewise be compelled "to take due precautions."

CHAPTER II.

RESULTS OF MALARIA PREVENTION IN BOMBAY.

Section 1.

280. RESULTS OF MALARIA PREVENTION UP TO 1909.—As has already been shown, the City of Bombay has frequently suffered from periods of ill-health in the past and in the early days of the British occupation many efforts were made to improve matters by the reclaiming of "drowned lands" and other measures. Of the results of these measures it is difficult, if not impossible, to judge. Undoubtedly much of the work undertaken was carried out on the assumption that, the salt marshes were responsible for the ill-health of the community; but as we have seen in another chapter there is little evidence to show that malaria was more prevalent in the past than in recent years; and it is exceedingly doubtful if the measures carried out from time to time had any appreciable effect upon this disease.

281. The work carried out by the Napiers at Colaba shortly after 1840 was supposed to have been followed by a reduced prevalence of malaria among the British troops stationed in the Cantonment there, who had suffered very severely for some years previously; and except for the fact that there is no evidence to show that Colaba was very malarious before the commencement of the Colaba Causeway, it might be thought that this was an instance of success attending anti-malaria work. But in the light of experience we are justified in assuming that malaria increased and became a menace to the health of Colaba because of the reclamation work going on there; and that after the completion of the work the epidemic declined, as is usual in such cases; and though it is probable that the measures carried out by the Napiers assisted in some degree to improve matters, it is exceedingly doubtful if this work was the main factor in producing an improvement in the public health. The introduction of a pipe-water supply and the closure of wells in the Cantonment, at a much later period, probably had a greater effect in reducing endemic malaria in this part of the island, than the special measures adopted twenty years before.

282. As regards measures of drainage, etc., in other parts of the City, there is no evidence to show that these have influenced malaria to any great extent and the fact that the portions of Bombay that have been longest drained are now more malarious than the parts of the island which are still undrained, negatives the view that such general measures have produced any reduction of malaria in the City.

283. In more recent times the history of events at Colaba has been repeated on a small scale both at Malabar Hill and Bhandarwada. Between 1872 and 1879 a large reservoir and settling tank was constructed on Malabar Hill. There is no reason to suppose that the area was very malarious before this, but partly in consequence of this work and partly as a result of the leakage which took place from the reservoir, malaria became prevalent in that neighbourhood. In 1880-1885 further work was carried out in connection with the water works on Malabar Hill, over 4 lákhs of rupees being spent upon filter-beds etc.; and again in 1903-1907 another 2½ lákhs were spent upon enlarging the works there. Whether or not the operations conducted in 1880-1885 gave rise to malaria, is not known, but there is evidence that during the progress of the later work malaria again became prevalent in the neighbourhood. Owing to the complaints that were made during 1905-1907 by the residents in the vicinity of the reservoir, certain preventive measures have been carried out from time to time in that locality, and it is now customary to ascribe the whole of the improvement which has followed, to the results of this work; but it is probable that the completion of construction work has been one of the main factors responsible for the lessened amount of infection.

284. There is a similar history regarding the occurrence of malaria and its prevention at Bhandarwada reservoir. There is no reason to suppose that

malaria was very prevalent in that part of Mazagaon before the construction of the Bhandarwada reservoir and six filter-beds in 1880-1884. But since that time the locality has obtained the reputation for being malarious; and there is evidence to show the existence of a certain amount of infection in the neighbourhood at the present time. A few years back three new filter-beds were constructed there and the reservoir was altered. As at Malabar Hill, so at Bhandarwada, this work appears to have led to a temporary increase of malaria, which aroused complaints; and as a result, measures have been taken from time to time to improve matters. The measures adopted, which consisted chiefly in attempts to stop leakage and the provision of masonry channels for waste-water etc., have no doubt been of considerable service, but it is probable that much of the improvement effected has been largely accidental. At the present time all the filter-beds and the reservoir itself continue to breed large numbers of malaria-carrying species of anopheles and if extensive construction works, necessitating the employment of large numbers of labourers, were undertaken there, an increase of malaria would again take place and a small local epidemic of the disease would be certain to follow.

285. In 1902, as has already been mentioned in "the History of Malaria Prevention," the Municipal Corporation decided to carry out general anti-mosquito measures in the City, and for this purpose a small gang of men was appointed. The special staff appears to have been discontinued after 1904, and since then anti-mosquito work has been carried out by the ordinary staff of the Health Department.

286. What has been the result of the work carried out on the lines indicated? The total recorded fever mortality is much less than it used to be and the fall coincided with the commencement of anti-mosquito work, so that at first sight it might be supposed that the one was related to the other. But examination of the Health Reports for 1902 shows that, an entirely new system of death-registration was introduced that year; a very large staff of qualified medical men was appointed for the express purpose of verifying the causes of death; and the fall in fever deaths was due not to better sanitation but to improved registration.

287. That better diagnosis rather than any sanitary improvement was responsible for the reduced fever mortality is shown by the fact that almost the whole of the reduction took place among Hindus and Mussalmans. Among Parsis the deaths from fever remained much the same after 1902 as before it, the mean annual total of deaths recorded under this head being 133 for the five years prior to 1902 and exactly the same figure 133, for the five years 1904 to 1908.

288. Excluding the work at Malabar Hill and Bhandarwada Hill it is exceedingly doubtful if the general anti-mosquito measures adopted in the City since 1902 have had much influence upon the incidence of malaria. Here and there mosquitoes have been lessened in number, but the mosquitoes dealt with have often been species of Culex, which as is well known, are not concerned in the spread of malaria. On the other hand there is reason to believe that malaria has actually increased rather than diminished during the period when supposed anti-malaria work has been in progress and on a number of occasions between 1902 and 1908 local outbreaks of malaria have taken place.

289. There was an increase of malaria associated with construction work at Malabar Hill reservoir; an increase at Colaba, associated with the recent reclamation work there, during which the cases of fever attending the local dispensaries rose from 2,559 in 1905 to 4,357 in 1906, a sudden increase of 70 per cent.; and the epidemic of malaria associated with the New Dock Work, which really began in 1905, a year after the work commenced as shown by the admissions for fever to the local dispensary.

Admissions of fever cases at Frere Road Dispensary.

1903.	1904.	1905.	1906.	1907.	1908.
2,074	2,984	4,036	4,852	6,584	7,173

290. In addition to these three epidemics which have occurred in the past few years, it is probable that there have been minor increases of malaria associated with the demolition of the areas required by the Improvement Trust for Sandhurst Road and Princess Street, and also for the building of new chawls at Koliwada. These local epidemics have all been due to similar causes, *i.e.*, the undertaking of construction work involving the production of numerous temporary pools of water in areas in which permanent breeding places of the malaria-carrying *Neocellia stephensi* existed, and in which the population was already in some degree infected with malaria. The gradual increase of endemic malaria in many parts of the City, resulting in many thousand of people becoming infected with the disease, culminated in a more general epidemic in 1908, in all probability partly as a result of the stress produced among the poorer classes of the population by the abnormal rise in the price of food in the latter part of 1907 and 1908.

291. As a general conclusion it may be stated that a consideration of all the available facts leads to the opinion that, the anti-malaria work carried out in the City prior to 1909 (with the exception perhaps of work at Malabar Hill and Bhandarwada) has failed to prevent an increase of malaria.

Section 2. 292. RECENT RESULTS OF MALARIA PREVENTION.—In 1909 shortly after the commencement of the special investigation, the results of which are detailed in this report, more vigorous measures of malaria prevention were adopted in the City, especially in the neighbourhood of the Docks. These measures have been referred to at length in a former section, and it is only necessary to mention certain facts which appear to show that the measures adopted have been of some value, and that a mitigation of malaria has followed upon their adoption.

In support of this opinion it may be pointed out that—

(1) There has been a considerable reduction in the spleen rate of children resident within the area in which the measures have been applied.
(2) There has been a marked reduction in the cases of fever admitted to the local dispensaries.
(3) There has been a fall in the total mortality among people resident in the area affected by malaria owing to proximity to the Dock Works.
(4) And more especially the mortality during October and November and the deaths among young children within this area has shown a great decrease.

293. *Spleen Rate.*—Early in 1909 before the adoption of the more vigrous measures subsequently undertaken by the Municipality, Port Trust and Railway Companies, an examination of 597 children resident in the Esplanade section, the area immediately adjoining the New Dock Works, showed 438 or 73·38 per cent. to possess enlarged spleen. A second spleen census carried out in this area late in 1910 showed 250 children out of 516 to have enlarged spleen or 48·4 per cent., a difference of nearly 25 per cent. A similar reduction has also been effected in the spleen rate among children resident in the portion of the North Fort which lies between Frere Road and the New Docks. Early in 1909 among 366 children resident there 166 or 49·4 per cent. showed enlarged spleen. Late in 1910 among 560 children examined there 200 or 35·7 per cent. showed enlarged spleen, a reduction of 13 per cent. In one large chawl with a population of 1,200 the spleen rate dropped from 54 per cent. to 29 per cent. at the end of 1909.

294. *Fever admissions.*—The fall in cases of fever admitted to the Frere Road dispensary is equally striking. The total fever admissions at this dispensary year by year since 1903 are as follows:—

Year.	Total fever cases treated.	Total cases treated.	Percentage of fever cases.
1903 ...	2,074	5,014	41·3
1904 ...	2,984	6,605	45·1
1905 ...	4,085	8,367	48·5
1906 ...	4,852	10,160	47·7
1907 ...	6,584	11,420	57·6
1908 ...	7,173	11,686	61·3
1909 ...	4,240	8,158	51·9
1910 ...	4,012	7,951	50·4

295. The monthly returns show that the fall in fever admissions has been most marked in October and November.

Admissions for Malaria, Municipal Dispensary No. 1 at Frere Road, Fort Section, A. Ward.

Month.	1906.	1907.	1908.	1909.	1910.
January	350	379	360	254	*212
February	339	268	249	232	215
March	402	356	375	267	205
April	306	329	466	249	238
May	259	457	769	321	288
June	277	531	618	418	322
July	397	606	569	408	457
August	555	806	718	479	465
September	480	759	851	567	373
October	512	992	1,088	420	510
November	571	578	719	353	387
December	404	523	391	271	342
Total ...	4,852	6,584	7,173	4,241	4,012

* It must be noted that in 1909 (from August to December 31st) over 4,000 people residing in the area covered by this dispensary were receiving house to house treatment with quinine. This was discontinued during 1910.

296. *Mortality.*—The areas which have undoubtedly been influenced by malaria owing to their proximity to the Dock Works are—

Esplanade.
Mandvi.
Chakla.
North Fort (a portion).

The total deaths recorded in these sections during the past four years are as follows :—

	1907.	1908.	1909.	1910.
Esplanade	611	801	679	626
Mandvi	1,661	1,566	1,309	1,374
Chakla	1,311	1,246	1,088	1,096
North Fort	1,125	1,144	1,033	1,126

297. The deaths by quarters in each of these sections during the past four years are shown below :—

Section.	Year.	1st quarter.	2nd quarter.	3rd quarter.	4th quarter.
Esplanade	1907	154	134	127	196
	1908	229	196	137	239
	1909	219	171	131	158
	1910	183	185	134	124
Mandvi	1907	517	393	365	386
	1908	371	426	343	426
	1909	319	429	253	338
	1910	391	317	304	335
Chakla	1907	442	346	242	281
	1908	366	283	243	254
	1909	329	232	200	227
	1910	302	287	248	259
North Fort	1907	347	230	277	271
	1908	295	342	217	292
	1909	310	276	203	244
	1910	269	321	285	251

298. October deaths recorded in these sections are given below.

	Esplanade.	Mandvi.	Chakla.	North Fort.	Total.
1907 ...	67	152	92	91	402
1908 ...	98	178	109	103	488
1909 ...	48	125	92	80	345

299. The total of October and November deaths for these four sections together since 1905 are as follows:—

1905.	1906.	1907.	1908.	1909.
594	696	747	846	649

These figures all show a considerable reduction in mortality in 1909 as compared with both 1907 and 1908.

300. Still more interesting are the mortality figures of a large chawl situated within the affected area. This chawl, which belongs to the Bombay City Improvement Trust, lies between Palton Road and the Railway Yards, and overlooks the New Dock Works. The population of the chawl is about 1,200. In 1907 and 1908 the residents suffered very severely from malaria. Early in 1909 the spleen census among children living there showed 56 per cent. with enlarged spleen, and the blood examination of a large number of adults and children showed an infection index of nearly 40 per cent.

During 1909 quinine was administered to about 800 men, women and children in this chawl. At the commencement of the treatment quinine pills were used, but they proved unsatisfactory and when sugar-coated tablets became available it was found that they were much more readily accepted than pills. At first only children with enlarged spleen were treated, but as blood examination showed that both children and adults with no palpable splenic enlargement were infected in nearly as great a proportion as those with enlarged spleen, it was decided to extend treatment to everyone who would accept it, and by the end of August 1909 over 800 men, women and children were in receipt of the remedy. The drug was discontinued during 1910, but the anti-mosquito measures begun in August 1909 in the New Docks, the adjoining Railway Yards and in the neighbourhood of the chawls were continued.

301. The mortality in these chawls during the past four years has been as follows:—

Year.	Mean population.	Deaths among adults.	Deaths among children.	Total deaths.	Death-rate per 1,000 per annum.
1907	859	*12	*5	*17	*59·3
1908	1,154	38	28	66	57·3
1909	1,234	36	24	60	48·6
1910	1,197	27	10	37	30·9

* Deaths in 1907 from September only.

302. The total deaths by months during the past four years has been as follows:—

Month.	1907.	1908.	1909.	1910.
January	...	2	5	4
February	...	3	7	4
March	...	4	8	1
April	...	6	5	5
May	...	1	3	3
June	...	8	4	2
July	...	4	7	6
August	...	7	2	3
September	1	6	6	2
October	7	9	2	2
November	5	7	7	2
December	4	9	4	3
Total ...	17	66	60	37

303. Taking the period from August to December for each of the three complete years we find the deaths have been as follows:—

Year.	Deaths.	
1908	38	August to December.
1909	21	„ „
1910	12	„ „

The deaths among young children during this period is as follows:—

Year.	Deaths.	
1908	21	August to December.
1909	8	„ „
1910	0	„ „

Comparing the total mortality for the fourth quarter of the year for each year since 1907 we get:—

1907.	1908.	1909.	1910.
16	25	13	7

304. When considering all the evidence which points to a mitigation of malaria having taken place in the area near the New Docks it must be borne in mind that, *the reduction in the spleen rate, the admissions for fever, and the deaths during the malarious season of the year, have occurred, not after the completion of work upon the Docks, which in itself would be certain to lead to such a reduction, but while the work is still in progress.* Up to the end of 1910 only 65 per cent. of the excavation work upon the new docks and 65 per cent. of the masonry had been completed and it will probably be another two years before the work is finished.

305. Climatic conditions too have not been favourable, for the rainfall of the past five years has been as follows:—

1906	56·30 inches.
1907	100·78 „
1908	53·54 „
1909	71·22 „
1910	67·86 „

Thus in 1909 and 1910 the rainfall has been heavier than in 1908 when malaria was at its maximum.

306. The only favourable influence, apart from the preventive measures adopted, has been a fall in the price of food. The average prices of wheat, jawar, bajri and rice during the past five years have been as follows:—

Seers of grain for the Rupee.

Year.	Wheat.	Jawar.	Bajri.	Rice.
1906 ...	9·44	11·78	11·94	8·27
1907 ...	9·39	12·22	13·23	8·12
1908 ...	6·54	9·83	9·83	6·64
1909 ..	6·63	10·79	10·97	8·30
1910 ...	6·78	11·46	10·79	9·08

The rise in prices during 1908 undoubtedly produced considerable stress among the poorer classes and this acting upon a malaria-infected population was probably one of the factors which helped to bring about the epidemic of 1908; but the fall of prices in 1909 and 1910 though an ameliorating influence would not account for the whole of the improvement recorded above.

307. *Results of work in other areas.*—It is at present impossible to point to the effects of the preventive work in other parts of the City, but the following paragraphs extracted from the Health Officer's reports gives some idea of the work that has been done.

Extract from the Report of the Executive Health Officer for 1909.

"The work accomplished with the aid of the special staff during the "three months (1st October to 31st December 1909) covered by this Report "may thus be tabularly indicated :—

1.	Wells examined for mosquito larvae	2,507
2.	Cisterns „ „ „	3,107
3.	Tanks „ „ „	144
4.	Wells in which larvae were found	908
5.	Cisterns „ „	255
6.	Tanks „ „	40
7.	Cases in which requisitions were addressed to parties ...	721
8.	Cases of compliance	129
9.	Cases in which sanction of the Standing Committee was sought for taking action (section 381 of the Act) ...	111
10.	Notices issued against parties	13
11.	„ complied with	...
12.	Prosecutions undertaken	2

"The permanent sanitary staff of the Department, however, continue "to weekly inspect, for mosquito larvae, the storm water entrances, gully "traps, catch-pits in their respective wards and treat them with pesterine as "culicide. Considerable opposition is met with from owners of wells and "much difficulty experienced in getting them covered. Possibly some incon- "venience arises from the measures which have to be adopted, but unfor- "tunately this is the case in every measure necessary for the protection of "Public Health. And if the owners of premises where mosquito-breeding "places are discovered would co-operate with us, an enormous amount of "labour and correspondence would be saved and much benefit would accrue "to the tenants and neighbours."

Extract from the Executive Health Officer's Report for the first quarter of 1910.

Anti-malarial work.

"So far as the work of this Department was concerned anti-malarial measures were continued during the quarter—inspection of wells, tanks, cisterns etc., and "the serving of notices and asking for the sanction of the Standing "Committee—but with very little practical result, as although up to "5th February sanction was given by the Standing Committee under "section 381 of the Municipal Act, to carry out that section in the case "of 298 persons, a week later a resolution was passed that all objections to "the closing of wells should be laid before the Standing Committee "and a week after a resolution was passed that all action should be stayed.

"Since the Malaria staff was appointed in October 1909, over 12,000 "inspections of houses have been made, and in every case where an "uncovered well or cistern has been found to contain mosquito larvae "letters have been written, and, if necessary, notices served and the "sanction of the Standing Committee applied for: 128 wells have been "covered, 48 filled in and 369 cisterns covered.

"The enormous amount of work done in respect of wells, tanks, cisterns, "etc., has now come to a standstill, in consequence of the last resolution "of the Standing Committee that a list of only those wells which are away "from light and air and of which the water is not used should be sent to the "Standing Committee, and a Sub-Committee will visit these wells and "decide what is to be done. Under these circumstances I have nothing "to say as to the result of the work done during the quarter; as "beyond the inspection and writing of letters and serving of notices to "the parties in whose premises such places exist nothing has been done, "beyond spending a considerable amount of time and money without any "practical result. When the Corporation in September 1909 resolved to "adopt measures for the control of malaria and agreed to the measures "I proposed, they also asked for a report at the end of six months: "in that report, which will be ready next week, I propose to explain the "position in detail."

Extract from the Executive Health Officer's Report for the second quarter ending 30th June 1910.

Malaria.

"As in the second quarter of 1909, Malarial Fever occasioned 42 deaths in the period under review, being 22 less than in the preceding quarter.

"Anti-malarial measures were continued during the quarter. Premises "were visited, wells, tanks, cisterns, etc., examined, and wherever mosquitoes "were found breeding in wells letters were addressed to parties to remedy "the situation, with the result that 58 wells were covered and 24 filled in.

"In accordance with the orders of the Standing Committee 118 wells "were reported to them as being 'the most objectionable cases,' out of "which 15 wells were visited and inspected by the Sub-Committee, who "recommended 7 of them to be hermetically sealed or filled up; and these "are under action; lists of remaining cases have been returned to this "Department to ascertain the objections, if any, of the owners to comply "with the requisitions of this Department."

Extract from the Executive Health Officer's Report for the third quarter ending 30th September 1910.

Anti-malarial work.

"In my previous Quarterly Reports I have dwelt on the anti-malarial work done during each period under review. But as it is now exactly a year since "the anti-malarial operations were commenced (1st October 1909) with the "aid of a special staff, the work done during the 12 months has been "tabulated below :—

Wells examined and re-examined for Mosquito Larvae ...	5,075
Cisterns „ „ „	8,516
Tanks „ „ „	389
Wells in which larvae were found	2,680
Cisterns „ „	994
Tanks „ „	117
Cases in which letters of requisition were addressed to parties ...	2,128
Cases in which they were complied with	713
Cases in which sanction of the Standing Committee to take action under section 381 of the Act was applied for	282
Cases reported as "most objectionable"	167
Notices issued against parties	99
„ complied with	21
Prosecutions undertaken	24

"I have in my First Quarterly Report for the year pointed out the "limitations under which this work is proceeding; progress under such "conditions must be slow. During the quarter under report only 13 wells "were filled in and 41 hermetically covered. Seven wells were mentioned in "my Second Quarterly Report as being then under action; the owners of the "three of these wells were prosecuted for non-compliance with the demands "of this Department but the proceedings were withdrawn as our requirements "were in the meanwhile complied with; in one case the party was warned "and discharged and three are pending.

"During the quarter 49 wells have been reported to the Standing "Committee as being the 'most objectionable cases', but no orders have "yet been received from that body."

Extract from the Executive Health Officer's Report for the fourth quarter of 1910.

Anti-malarial operations.

"Anti-malarial investigations were continued during the quarter as in the past, and 29 wells were reported to the Standing Committee as being 'worst cases.'

"33 wells were hermetically covered and 14 filled in as under:—

Ward.	No. of wells heremetically covered.	No. of wells filled in.
B.	15	6
C.	3	.....
D.	6	3
E.	8	5
F.	1	.....

"During the period under review the Malaria Sub-Committee of the "Standing Committee issued their third and fourth reports, both of "which were adopted by the Standing Committee: the latter embodies "definite measures to be taken against 70 of the wells reported against "by this Department."

308. *Protection of Wells.*—From information received recently it appears that up to the end of 1910 the total number of wells reported as dealt with by the Health Department was as follows:—

Wards.	A.	*B.	*C.	D.	E.	F.	G.	Total.
Filled in ...	22	22	22	31	20	...	1	118
Covered with masonry or wire gauze ...	63	32	64	86	27	1	...	273
Total ...	85	54	86	117	47	1	1	391

* In the list received a number of wells situated in C. Ward were given as belonging to B Ward, and it is quite possible the figures for these two Wards are not quite accurate although the total is given correctly.

It may be mentioned that the above list appears to include a certain number of wells filled in some years ago; and in other cases wells described as filled in or covered are still open.

The Executive Health Officer in a communication respecting the wells dealt with remarks—

"It may be stated here that consequent upon the unavoidable delay "that was caused in the issue of definite orders by the Standing Committee, "as regards the preventive measures to be adopted in respect of wells "breeding larvae of malaria-carrying mosquitoes, some of the wells which "were formerly covered were reopened during the interval."

CHAPTER III.

THE LEGAL ASPECT OF MOSQUITO PREVENTION.

Section 1. 309. NECESSITY FOR LEGAL POWERS.—It is sometimes assumed because a private person may find little difficulty in preventing the breeding of mosquitoes on his premises, if he is willing to take the necessary precautions, that it is a comparatively simple matter for public bodies like municipalities to do the same thing in the areas under their control. But a little experience shows this idea to have no foundation, for the officials charged with carrying out sanitary measures within the bounds of a municipality meet with every sort of objection and opposition, especially in the use of new measures not sanctioned by custom or supported by precedent.

It is only twelve years since Ross first proposed mosquito destruction or prevention as a sanitary measure, and it has been found in many places in which this form of sanitation has been adopted that, it was necessary to supplement existing enactments relating to the Public Health, by Ordinances and Bye-laws, framed for the specific purpose of preventing the breeding of mosquitoes and giving special powers to the sanitary authority to carry out the measures of prevention found necessary for this purpose.

310. Colonel Gorgas, who was the first medical officer to carry out a successful anti-mosquito campaign in a large city, reported in 1901, shortly after the commencement of this work in Havana, that—

> "the Mayor has issued an order prohibiting the keeping of standing "water anywhere within the City limits unless made mosquito proof. This "is being enforced; and all standing water found not protected as required "is emptied and the owner fined."

311. Ross in his report upon malaria in Mauritius, mentions that for purposes of malaria prevention certain petty laws and regulations are necessary; and in his more recent book upon "The Prevention of Malaria," in detailing the first step to be taken by an authority proposing to reduce malaria, he states that it is necessary to reconsider the local Government and Municipal sanitary regulations in order to take power to deal with mosquitoes. He summarises the objects for which such legislation is required as follows:—

> "Briefly such enactments must give the Health Department power—
>
> "(*a*) to enter private premises (including houses, yards, gardens, "lands and estates) in order to search for mosquitoes, rats and other "annoying or dangerous vermin;
>
> "(*b*) to destroy such vermin when found; and
>
> "(*c*) to prevent the breeding of them.
>
> "Another object is to compel owners or occupiers to take reasonable precautions against such breeding."

Ross points out that although most civilized malarious countries now possess Health Acts, more or less based upon precedent, and these contain clauses against "nuisances," the word nuisance is not always defined so as to include the breeding of vermin. He adds:—"In such cases, then, it suffices merely to extend by Act the definition of the word, if possible to include all vermin as well as mosquitoes."

312. Colonel Gorgas, in a recent paper upon mosquito prevention, after stating that the first thing in undertaking such a work is to get the necessary funds, adds:—

> "The next step is to get the authority necessary for enforcing the "sanitary measures. To this end I would have an ordinance passed declaring "it a nuisance for any property owner to have on his premises any mosquito "larvæ, and prescribing a fine of from 5 to 10 dollars for such offence. The "Sanitary Officer should have powers, so far as these sanitary ordinances "are concerned, such as the alcaldes of most Latin-American municipalities

"have. This would give the Sanitary Officer the power of assessing the "fines or revoking them at any stage of the proceedings. The fine should "be collected through the Courts, but the Sanitary Officer should be officially "informed by the Judge when the fine is collected, and also by the treasurer "when the fine has been deposited in the treasury. In this way he can "keep control of all the steps in the process.

"Another ordinance should be passed giving the sanitary officer autho-"rity to abate these nuisances himself with his own force when they have "not been abated by the owner of the property after a week's notice and "providing that the cost of such work be made a lien against the property— "which cost is to be collected through the Courts against the owner of the "property. This is a very important measure, as it enables the sanitary "officer at no great public expense rapidly to carry into effect his sanitary "measures himself when the people affected are slow in executing the "measures ordered.

"A third ordinance should be passed directing that all cisterns, wells, "gutters and water collection likely to breed mosquitoes must be either "abolished or so screened and cared for that mosquitoes cannot breed in "them. With these three ordinances the Health Officer can rapidly get his "community in such condition that very few stegomyiæ can breed, and "the locality will soon be in such condition that there will be so few "stegomyiæ that Yellow fever cannot spread."

313. At the present time nearly every British Colony in the West Indies possesses special Public Health ordinances for the prevention of mosquito breeding, which enforce the drainage, screening and protection of collections of water; and prescribe heavy penalties in cases of default. Similar ordinances have also been passed in certain cities in the United States. A number of the special ordinances and bye-laws in the West Indies were quoted in full in the appendix to the *ad interim* report upon Malaria in Bombay published early in 1910.

Section 2. 314. THE CITY OF BOMBAY MUNICIPAL ACT.—In Bombay the sanitary administration is conducted under powers contained in certain sections of the City of Bombay Municipal Act, and it is necessary to examine these sections carefully in order to determine how far they meet the requirements of mosquito prevention and in what direction they need modification.

315. **Section 3 of the Act** is devoted to definitions, among which the three following are of importance in relation to the prevention of mosquitoes and malaria :—

Definition (*t*)—

"*Water work*" includes a lake, stream, spring, well, pump, reservoir, cistern, tank, duct, whether covered or open sluice, mainpipe, culvert, engine and any machinery, land, building or thing for supplying or used for supplying water.

Definition (*z*)—

"*Nuisance*" includes act, omission, place, or thing which causes or likely to cause injury, danger, annoyance or offence to the sense of sight, smelling or hearing, or which is or may be dangerous to life or injurious to health or property.

Definition (*aa*)—

"*Dangerous disease*" means cholera and any endemic, epidemic or infectious disease by which the life of man is endangered.

316. Under **section 61 of the Municipal Act** it is incumbent on the Corporation to make adequate provision for the following matters among others :—

(*a*) The construction, maintenance and cleansing of drains and drainage works, and of public latrines and similar conveniences.

(*b*) The construction and maintenance of works and means for providing a supply of water for public and private purposes.

(*d*) The reclamation of unhealthy localities, the removal of noxious vegetation and generally the abatement of all nuisances.

(*g*) Measures for preventing and checking the spread of dangerous diseases.

317. **Section 64 of the Act** which deals with the functions of the several municipal authorities lays down :—

Sub-section (*3*)—

Subject, whenever it is in this Act expressly so directed, to the approval or sanction of the Corporation or the Standing Committee and subject also to all other restrictions, limitations and conditions imposed by this Act, the entire executive power for the purpose of carrying out the provisions of this Act vests in the Commissioner . . . . . etc.

318. **Section 68** lays down that—(1) Any of the powers, duties or functions conferred or imposed upon the Commissioner by any of the sections, sub-sections or clauses mentioned in *sub-section* (*2*) may be exercised, performed or discharged, under the Commissioner's control and subject to his revision and to such conditions and limitations, if any, as he shall think fit to prescribe, by any municipal officer whom the Commissioner generally or specially empowers in writing in this behalf; and in each of the said sections, sub-sections and clauses the word "Commissioner" shall, to the extent to which any municipal officer is so empowered, be deemed to include such officer.

It is important to note that, among the list of sections, sub-sections, and clauses referred to in *sub-section* (*2*) of the above **section 68**, *sections 374, 377, 488 and 489* are included, **but section 381**, *which is the most important one in the Act from the point of view of mosquito prevention, is excluded.*

319. Provisions as to storage cisterns and other fittings, etc., to be used for connections with water-works are laid down in **section 274**, of which *sub-section* (*1*) reads as follows :—

"The Commissioner may, whenever it shall appear to him to be "necessary, by written notice require that any premises furnished with a "private water-supply from any municipal water-work shall, within a reason-"able period, which shall be prescribed in the said notice, be provided with "a storage-cistern of such size, material, quality and description, and with "such fittings and placed in such position as he thinks fit."

320. **Section 279** gives power to the Commissioner with the sanction of the Standing Committee to cut off private water supply or to turn off water if the owner neglects to comply with a notice regarding the provision of a storage cistern.

321. **Section 374** which gives power to inspect premises for sanitary purposes reads as follows :—

"The Commissioner may inspect any building or other premises for the purpose of ascertaining the sanitary condition thereof."

322. But "Power of Entry" is laid down definitely in **section 483** as follows :—

Section 488.—The Commissioner may enter into or open any building or land, with or without assistants or workmen, in order to make any inspection or survey or to execute any work which is authorized by this Act or by any regulation or by-law framed under this Act to be made or executed, or which it is necessary for any of the purposes, or in pursuance of any of the provisions, of this Act or of any such regulation or by-law, to make or execute :

Provided that—

(*a*) except when it is in this Act otherwise expressly provided no such entry shall be made between sunset and sunrise;

(*b*) except when it is in this Act otherwise expressly provided, no building which is used as a human dwelling shall be so entered, unless with the consent of the occupier thereof, without giving the

said occupier not less than twenty-four hours' previous written notice of the intention to make such entry, and unless for any sufficient reason it shall be deemed inexpedient to furnish such information of the purpose thereof;

(*c*) sufficient notice shall in every instance be given, even any premises may otherwise be entered without notice, to enable the inmates of any apartment appropriated to females to remove to some part of the premises where their privacy need not be disturbed;

(*d*) due regard shall also be had, so far as may be compatible with the exigencies of the purpose for which the entry is made, to the social and religious usages of the occupants of the premises entered.

323. **Section 377** deals with neglected premises:—

(1) If it shall appear to the Commissioner that any premises are overgrown with rank and noisome vegetation, or are otherwise in an unwholesome or filthy condition or, by reason of their not being properly enclosed, are resorted to by the public for purposes of nature, or are otherwise a nuisance to the neighbouring inhabitants, the Commissioner may, by written notice, require the owner or occupier of such premises to cleanse, clear or enclose the same, or, with the approval of the Standing Committee, may require him to take such other order with the same as the Commissioner thinks necessary.

(2) Provided that, in so far as the unwholesome or filthy condition of such premises or such nuisance as above mentioned is caused by the discharge from or by any defect in the municipal drains or appliances connected therewith, it shall be incumbent on the Commissioner to cleanse such premises.

324. **Section 381.** Filling up of pools, etc., which are a nuisance:—

If, in the opinion of the Commissioner, any pool, ditch, tank, well, quarryhole, low ground or stagnant water is or is likely to become a nuisance, the Commissioner may, with the approval of the Standing Committee by notice in writing, require the owner thereof to cleanse, fill up, drain off or remove the same or to take such other order therewith as the Commissioner shall deem necessary.

The only sections of the Act which appear to have been used in connection with the attempts to suppress mosquitoes are Nos. 374 and 488, 377 and 381, and of these the last is the most important.

325. Power is given to the Commissioner under **section 439 of the Act** to cause any necessary work to be executed and to recover the cost. This section provides that in the event of non-compliance with a requisition or order, made by written notice by the Commissioner or by any municipal officer empowered under **section 68** in this behalf for the carrying out of any of certain provisions of the Act, the Commissioner may cause the work to be executed, and the expense shall be recoverable from the person to whom the requisition was addressed.

Sections 377 and 381 are included among the sections to which this provision applies, but it must be pointed out that under the Act (**section 68**) *apparently no municipal officer can be delegated by the Commissioner to carry out* **section 381,** *and the Commissioner himself can only act with the approval of the Standing Committee.*

326. **Section 434.**—(1) In the event of the city being at any time visited or threatened with an outbreak of any dangerous disease, or in the event of any infectious disease breaking out or being likely to be introduced into the city amongst cattle—including under this expression sheep and goats,—

Commissioner may take special measures on outbreak of any dangerous disease.

the Commissioner, if he thinks the ordinary provisions of this Act or of any other law at the time in force are insufficient for the purpose, may, with the sanction of Government,—

(*a*) take such special measures, and

(*b*) by public notice prescribe such temporary regulations to be observed by the public or by any person or class of persons,

as he shall deem necessary to prevent the outbreak of such disease or the spread thereof.

(*2*) The Commissioner shall forthwith report to the Corporation any measures taken and any regulations prescribed by him under *sub-section* (*1*).

327. **Under section 461 of the Act** the Corporation is empowered to make bye-laws from time to time, not inconsistent with the Act, with respect to the following among other matters :—

(*a*) Regulating, in any particulars not specifically provided for in this Act, the construction, maintenance and control of drains, ventilating shafts, or pipes, cesspools, water-closets, privies, latrines, urinals, drainage-works of every description, whether belonging to the Corporation, or to other persons, municipal water-works, private communication-pipes and public streets ;

(*b*) Regulating all matters and things connected with the supply and use of water.

At present there do not appear to be special by-laws relating to the above matters.

328. Penalties under the Act are prescribed as follows :—

Section 471.—Whoever—

(*a*) contravenes any provision of any of the sections, sub-sections or clauses mentioned in the first column of the following table or of any regulation made thereunder ; or

(*b*) fails to comply with any requisition lawfully made upon him under any of the said sections, sub-sections or clauses,

shall be punished for each such offence with a fine which may extend to the amount mentioned in that behalf in the third column of the said table.

In the table which follows the fine which may be imposed under **section 377** amounts to Rs. 50 and that under **section 381** to a similar amount.

329. **Section 472** lays down that anyone who after having been convicted of contravening certain sections of the Act or failing to comply with any lawful requisition may be punished with a fine for each day that he continues to offend. A daily fine of Rs. 5 may be imposed in respect of default under both **sections 377 and 381.**

330. Finally, under **section 518** power is given to the Governor in Council, if upon complaint being made to him and after enquiry it appears that the provisions of certain sections of the Act have not been or are not being duly carried out and enforced, to make an order prescribing a period within which such provision is to be carried out or enforced.

Sections 61 and 434 are included in the list of sections referred to.

Sub-section (*3*) of **section 518** empowers the Governor in Council to appoint some person to carry out and enforce the provisions of any order made under *sub-section* (*1*) of this section if action has not been taken after due notice.

331. At present a proposal for amending **section 381** is under discussion. The proposed amended section would read as under :—

Section 381. If in the opinion of the Commissioner—

(*a*) any pool, ditch, tank, pond, well, quarryhole, drain or water-course, or

(*b*) any cistern or other receptable for water, whether within or outside a building, or

(*c*) any low-lying or other land on which water accumulates and which is situate within a distance of 100 yards from any building used as a dwelling house,

is, or is likely to become, a breeding place of mosquitoes, or in any other respect a nuisance, the Commissioner may, with the approval of the Standing Committee, by notice in writing, require the owner thereof to fill up, cover over or drain off the same with such materials, and in such manner in all respects, as the Commissioner shall require, or to take such other order with the same for removing or abating the nuisance, as the Commissioner shall prescribe.

332. This is an improvement on the previous wording of the section, but it must be pointed out that the amendment on the lines suggested does not meet the requirements of the case for the following reasons :—

(1) Only potential breeding places already existing can be dealt with.

There is no power given under any section of the Act to prevent the multiplication of potential breeding places; and apparently any person can dig a well, construct a tank or fountain or place any number of tubs or vessels to contain water on his premises without let or hindrance.

(2) The powers enforced by the existing Act only permit the Municipal Commissioner to take action in regard to **section 381** *with the sanction of the Standing Committee*, and he cannot delegate his duties under that section to any municipal officer. Thus the Act as it stands at present does not legally oblige any person to take notice of a requisition under **section 381** until he has received an order in writing from the Municipal Commissioners and the Commissioner cannot issue such an order until the matter has been considered by the Standing Committee.

333. An example may be suggested of what might easily occur under existing circumstances. Suppose an officer of the Health Department discovers a large number of mosquito larvæ and pupæ of a dangerous species, breeding in a garden tub. He may call the attention of the owner to the fact, but legally he has no power to take any action, and if the owner objects to do anything himself and refuses to permit anything to be done, the officer would have to leave the tub alone; all he could do would be to report matters to the head of his department. In due course the case would be reported to the Municipal Commissioner, who in turn would place it before the Standing Committee. The Standing Committee, after considering the matter, would no doubt sanction the issuing of an order by the Municipal Commissioner to the owner to abate the nuisance; and the Commissioner himself might take action if after the expiry of the notice nothing has been done. But in the ordinary course of things the owner would be summoned before a Magistrate, and this would create a still further delay. No doubt the tub of the mosquito larvæ would be dealt with in the end, probably after the expiry of some weeks; but the same thing might happen again and again. This of course is an extreme case, but it is typical of the unwieldy methods that have to be adopted in Bombay under the present Act, and the proposed amendment of **section 381** does not suggest any simplification of this cumbersome procedure.

Section 3.

334. THE ADMINISTRATION OF THE ACT IN REGARD TO MOSQUITO PREVENTION.—The powers given under the various sections of the Municipal Act quoted above are much too vague to enable the Sanitary authorities to carry out mosquito prevention work with any assurance of success. Until the breeding of mosquitoes is declared to be a statutory nuisance and the Sanitary authorities are given adequate powers for dealing with the danger in an efficient manner, so that if necessary they can themselves abate the nuisance after short notice to the responsible party, it is doubtful if the breeding of the most dangerous species of mosquitoes can be controlled and the spread of malaria be prevented.

It has happened frequently that when persons are summoned before a Magistrate under **section 381** (as it stands at present) with a view to obtain the enforcement of an order to abolish or protect a collection of water that is the breeding place of mosquitoes, the case is dismissed. Quite recently in a case in which a house-owner had refused to obey an order to fill up a collection of water in which mosquitoes were breeding on his premises, the Magistrate dismissed the case, basing his decision on the statement of the defendant that

the hole in question was not a quarryhole, the term by which it had been described in the notice. The fact of its being a breeding place for mosquitoes was not disputed. In another case where a house owner refused to cover a cistern which was breeding mosquitoes, it was found that **section 381 of the Act** contained no provisions regarding cisterns, the word "tank" being held not to apply. In another case a man summoned for refusing to comply with an order to close a well, stated that there was no well on his premises and called witnesses to prove the fact. This was of course a mere legal quibble, there being a water-hole resembling a well on the premises; but the Magistrate dismissed the case and the breeding place of mosquitoes which the inspector called a well, and the owner something else, remained unprotected.

335. In his recent book on Malaria Prevention Major Ross states that—

> "A serious difficulty in the way of all sanitary improvement lies in the "inadequacy of punishment often given by legislators for sanitary contra- "ventions. These are too small to be deterrent. Endless petitions are "allowed; and the time of the Sanitary Department which should be spent "on useful work is used up in attending Courts and writing up cases—a "simple waste of public funds! This is not freedom but license. It is a "very low form of civilisation in which individuals are allowed to abuse "the freedom which civilisation has given them by poisoning or infecting "their neighbours ..... The success of the work at Panama has been "largely due to the stringent discipline exerted; and the public themselves "has become thankful for it ..... I would, therefore, strongly advise "the Government which determines upon a general war against malaria "to tighten up the reins in this matter."

336. Many of the Magistrates of Bombay will be found to discharge persons convicted under certain sections of the Municipal Act with a caution, or to inflict only a nominal penalty.

In the Administration Report of the City for 1908-1909 the Chairman of the Standing Committee makes the following comment regarding this fact :—

> "The Executive Engineer reiterates the complaint that in a large "number of cases the Magistrate held that offences had been committed and "yet did not inflict any penalty. Out of 463 cases decided, in as many as "180 cases parties were warned and discharged. The Standing Committee "have already suggested that the High Court may be moved to revise the "decisions in a few typical cases. If however this suggestion is not deemed "practicable an attempt may be made to elicit information as to the consi- "derations that influence the Magistrate's decision in such cases."

337. The fines inflicted for breaches of the sections of the Municipal Act relating to sanitation are also generally too small to act as a deterrent.

The following table gives the number of convictions under the Act obtained by the Health Department during the years 1900-1902 together with the fines inflicted :—

Year.	Total convictions.	Total amount of fines.	Total convictions under Sections 377 and 381.	Total of fines inflicted under Sections 377 and 381.
		Rs.		Rs.
1900	2,557	3,219	176	217
1901	1,891	1,755	166	185
1902	1,303	2,147	115	196

It will be seen from this that the average penalty inflicted in Bombay for disregard of sanitary regulations, is ridiculously inadequate.

338. It may not be out of the place to mention in this connexion certain facts in regard to the working of some of the Ordinances and Regulations against the breeding of mosquitoes in force in the West Indies. The following notes are recorded by Sir Rubert Boyce in his recent book on "Health Progress and Administration in the West Indies":—

(1) In Barbados, during the period March to May 1909, 99 persons "were fined sums varying from one to forty shillings for breeding mosquitoes "on their premises.

(2) *Trinidad.*—Return of prosecutions under Anti-mosquito Regula- "tions from 1st April to 8th December 1909:—

Total number of informations laid	152
Number fined (all convictions, with one exception)... ...	151
Number reprimanded and discharged—	
(The summons was served by mistake on the owner instead of on the occupier)	1
Kind of receptable in which larvæ were found :—	
Antiformicas	70
Barrels	64
Tubs	13
Disused tins	2
Eaves-gutters	2
Bottles	1
	152
Amount paid in fines	£28-8-6

"The fines varied from 1*s.* to 10*s.*

"Return of cases prosecuted by the Acting Sanitary Officer for breach of "regulations, under Order 188 of January 16, 1908:—

	Date of offence.	Offence.	Date heard.	Judgment.
1.	March 5, 1909...	Stagnant water in barrels.	March 16, 1909 ...	.....
2.	„ 17, 1909...	Stagnant water in barrels and tubs, with mosquito larvæ.	„ 26, 1909 ...	10*s.* fine or 7 days' imprisonment.
3.	April 17, 1909 ...	„ „ ...	April 23, 1909 ...	£3 or 14 days.
4.	„ 20, 1909 ...	„ „ ...	„ 29, 1909 ...	2*s.* 6*d.* or 7 days.
5.	„ „ ...	„ „ ...	„ „ ...	„ „
6.	„ 19, 1909 ...	„ „ ...	„ „ ...	„ „
7.	„ „ ...	„ „ ...	„ „ ...	„ „
8.	„ „ ...	„ „ ...	„ „ ...	„ „
9.	„ „ ...	„ „ ...	„ „ ...	„ „
10.	„ „ ...	„ „ ...	„ „ ...	„ „
11.	„ „ ...	„ „ ...	„ „ ...	„ „
12.	„ „ ...	„ „ ...	„ „ ...	„ „
13.	„ „ ...	„ „ ...	„ „ ...	„ „
14.	„ „ ...	„ „ ...	„ „ ...	„ „
15.	„ „ ...	„ „ ...	„ „ ...	„ „
16.	„ „ ...	„ „ ...	„ „ ...	„ „
17.	„ „ ...	„ „ ...	„ „ ...	„ „
18.	„ 21, 1909 ...	„ „ ...	„ „ ...	„ „
19.	„ „ ...	„ „ ...	„ „ ...	„ „
20.	„ „ ...	„ „ ...	„ „ ...	„ „
21.	„ „ ...	„ „ ...	„ „ ...	„ „
22.	„ „ ...	„ „ ...	„ „ ...	„ „
23.	„ 20, 1909 ...	„ „ ...	„ „ ...	„ „
24.	„ 22, 1909 ...	„ „ ...	May 3, 1909 ...	5*s.* or 7 days.
25.	„ 23, 1909 ...	„ „ ...	„ 5, 1909 ...	„ „
26.	„ „ ...	„ „ ...	„ „ ...	„ „
27.	„ „ ...	„ „ ...	„ „ ...	„ „
28.	„ „ ...	„ „ ...	„ „ ...	„ „
29.	„ 28, 1909 ...	„ „ ...	„ 7, 1909 ...	£1 or 14 days.

Summary of Prosecutions from 5th March to 28th April 1909.

"Twenty-nine prosecutions for keeping stagnant water in barrels or with "mosquito larvæ :—

1	heard on	March	16, 1909.
1	„	„	26, 1909.
1	„	April	23, 1909.
20	„	„	29, 1909.
1	„	May	3, 1909.
5	„	„	5, 1909.
29			

Convictions were obtained in all cases.

In 1	case	a fine of	10*s.*	was imposed.
1	„	„	£3	„
1	„	„	£1	„
5	„	„	5*s.*	were imposed.
20	„	„	2*s.* 6*d.*	„

"The fines were paid in all cases except that in which a fine of £3 was "imposed. The defendant elected to go to prison for 14 days."

Total fines paid £5 5*s.*

The following paragraph appeared in the Port of Spain Gazette of 6th August 1909 :—

> "For failing to keep their premises free from stagnant water liable to "breed mosquitoes, four persons were prosecuted at the City Police Court "yesterday. In each case a conviction was secured and the fine imposed of "5*s.* or seven days' imprisonment."

339. It will be seen from these notes that the majority of convictions and fines inflicted were for allowing mosquitoes to breed in *antiformicas*, barrels and tubs. Antiformicas, it may be mentioned, are small shallow vessels containing water, which are placed under the legs of tables, etc., to prevent ants from ascending.

340. There is no section in the present City of Bombay Municipal Act which would allow the authorities responsible for the health of the City to proceed against owners or occupiers of premises containing breeding places of this nature; and until an enactment is passed laying down clearly and inclusively that the breeding of mosquitoes in any and every collection of water is a breach of the law, and giving power to the sanitary authorities themselves to abate such nuisances, it is difficult to see how mosquito breeding is to be prevented in Bombay.

CHAPTER IV.

THE COST OF MOSQUITO PREVENTION.

Section 1.

341. THE COST OF MOSQUITO PREVENTION IN OTHER PARTS OF THE WORLD.—It is necessary to discuss the cost of mosquito prevention at some length, in order to arrive at an idea of the expenditure demanded by efficient work of this nature. Below are given certain figures relating to the staff employed and the expenditure incurred in a number of towns in the tropics in which anti-mosquito work has been undertaken.

342. *Ismailia.*—A town with a population of 8,000 people. No rainfall and no rivers or streams. All mosquito-breeding places artificial, including the irrigation channels and small marshes formed by leakage from the fresh water canal. For anti-mosquito work a gang, consisting of a European inspector and three men, was employed. They visited the houses and compounds in the town and destroyed any mosquito larvæ they found with kerosine and crude petroleum. In addition, some engineers and a number of workmen were employed in clearing gardens of all pools, puddles and stagnant water generally. The cost of the permanent work was Rs. 30,000. The annual cost of keeping the gardens and irrigation channels free of mosquito larvæ is now Rs. 4,875 and the oiling of the cess-pools and the general work of the mosquito brigade in the town is Rs. 6,562-8-0 per annum, of which Rs. 3,312-8-0 is spent on oil and Rs. 3,250 on salaries, etc. The cost of this regular work is now about Rs. 1-3-0 per head of the population per annum. In the early years the cost was Rs. 1-7-0 per head of the population.

343. *Port Said.*—Port Said has about 50,000 inhabitants and covers only a small area. It is practically surrounded by sea, being situated on a narrow triangular spit of land bordered by the Mediterranean, the Suez Canal and the shallow sea-water Lake of Menzalah. There are no rivers or streams and there is no rainfall. Two gangs, one of five and one of four men, each under the charge of a foreman, were engaged in anti-mosquito work. In 1907 41,120 gallons of oil were used and the cost of the work was about Rs. 18,380. In 1908 a large number of cellars, which used to become flooded with sewage, were filled with sand; and as a result only 31,670 gallons of oil were used and the total cost of the work (exclusive of the filling up of the cellars, which was done by the house-owners and required 17,000 cart loads of sand) amounted to about Rs. 16,000 or close upon 5 annas per head of the population of which the oil used cost Rs. 11,500 and the labour about Rs. 4,500. The cost of the work at Port Said is very much less than that at any other place.

344. *Havana.*—The City of Havana has a population of about 250,000 people crowded into a small area. The rainfall is heavy. In 1901 Gorgas commenced anti-mosquito work there. The number of men employed in the anti-stegomyia brigade was 75 and 150 men formed the anopheles brigade. The latter worked chiefly in the outskirts of the City. The work is still being continued. The City is now divided up into 63 districts each in charge of a sanitary inspector.

345. *Rio de Janeiro.*—A City of large area with 800,000 inhabitants and 85,000 houses. The rainfall is heavy. Anti-mosquito work was commenced in 1903. About 1,500 men were employed in destroying mosquito larvæ and others on fumigation, etc. The author of "Comment on assainit un pays", a pamphlet which describes the sanitary improvement effected at Rio de Janeiro, states that the amount expended yearly on anti-mosquito work is not less than 3,000,000 francs or about 18,75,000 rupees, a sum equal to more than Rs. 2 per head of the population per annum.

346. *New Orleans.*—A large City with 325,000 inhabitants. Because of Yellow Fever, anti-mosquito work was commenced in 1905. Boyce gives the total number of men employed on the work as follows:—

Total number of men employed in inspecting oiling and screening	910
Special Fumigating Division	156
Special Investigating Division	105
Purveyor's Department	32
	1,203

The total medical staff employed was fifty.

347. *Khartoum.*—This town, which is the capital of the Soudan, is divided into two portions by the Nile. The population is about 41,000; 16,000 on one bank and 25,000 on the other. There is little or no rainfall. There are 10 sanitary inspectors employed, 3 of whom are British and 7 natives: and when necessary a special staff is employed in filling-in pools near the river.

348. *Durban.*—A town in South Africa with a population of 60,244. Since 1905, £80,000 (Rs. 12,00,000) has been spent on filling-in and draining a swamp near the town. A mosquito brigade consisting of 2 Europeans and 50 Indians is engaged in temporary work.

349. *Klang and Port Swettenham.*—Klang and Port Swettenham are two small stations in the Federated Malay States, a country with heavy rainfall. When operations were first commenced the total population of the two places was about 4,000 people. The cost of filling in swamps and draining them was £10,000 (Rs. 1,50,000), and £410 (Rs. 6,150) is spent annually on anti-mosquito work.

350. *Free Town (West Africa).*—Population 30,000, rainfall heavy. This was almost the first anti-mosquito campaign attempted. Dr. Logan Turner was in charge of the work and in September 1901 he had 53 men employed, at wages of about £1 a month each. Dr. Daniels, the well known authority on Tropical Medicine, stated in a report on the work in 1901 that—

> "In the next wet season, double the men, say one hundred, should be "employed, and two Europeans for supervision. One European, even as able "and energetic a man as Dr. Logan Turner, barely suffices for thorough "supervision of the present work.
>
> "I am aware that this will cost, apart from the expense of super- "vision, over £100 a month instead of the £50 to £60 which, including the "cost of labour provided locally, is now spent."

"351. *Hongkong.*—Hongkong is sometimes quoted as an example of a large City in which anti-mosquito measures have been carried out with success. The measures adopted appear to have been directed mostly against anopheles mosquitoes and they seem to have been applied in only a few localities. Judging from the published accounts, the measures used consisted chiefly in the making of a few masonry channels down certain of the ravines which exist on the island, and the keeping of these channels in good order. The cost of this work has totalled about £6,500 or nearly one lakh of rupees. If the authorities in Bombay confined their efforts at mosquito prevention to the making of pucca channels on Malabar Hill, Cumballa and Bhandarwada Hills, and the destruction of mosquitoes in those localities the work would probably be about equivalent to what has been done in Hongkong.

352. *Cairo.*—Dr. H. C. Ross (brother of Major Ronald Ross), who has carried out anti-mosquito work in certain parts of Cairo and other places in Egypt, writes as follows:—

> "Cairo is a very much larger City than Port Said. It contains an "estimated population of more than half a million.....The town is situated on "the east banks of the Nile...Suburbs extend north and south, but the City "itself is compact, and, for its population, does not cover a very great "area.....Cairo is infested with mosquitoes. To destroy them throughout "the City would be a stupendous, but not impossible, task, and it would "involve an expenditure of about £20,000 annually."

"353. *Panama, etc.*—In a recent paper by Colonel Gorgas an estimate is given of the staff that would be required for general anti-mosquito work in a municipality containing a population of 30,000 people housed in 6,000 houses. The estimate is as follows:—

1 Health Officer.
10 Sanitary Inspectors.
2 Clerks.
1 Chief Carpenter.
2 Carpenter Foremen.
1 Head of cleaning squad.
4 Foremen.
1 Chief of ditching squad.
1 Foreman.
60 Labourers.

For this establishment excluding the salary of Health Officer the total annual cost at Panama rates would be 50,400 Dollars and at Bombay rates about Rs. 50,000. About Rs. 15,000 would be required for "material."

Gorgas further states in his letter that—

> "Such an organization, in my opinion, is all that is essential for "yellow fever prophylaxis. While street cleaning, garbage collection, "caring for nightsoil, etc., are very useful adjuvants to the general health "and good appearance of a municipality, they have no direct bearing on "yellow fever and the people of a poor community, that had little money to "spend, would be entirely justified, I think in adopting the organization "outlined, with the idea of keeping it up for a year or two, freeing their "locality from yellow fever, and considering the other municipal work "mentioned at some future time when they would be better able financially "to carry it out."

and he adds—

> "In the municipality the same measures that are directed against "yellow fever will avail against malaria."

He has recently estimated the cost of the anti-mosquito work conducted in the Panama Canal Zone at dollars 2 (just about Rs. 6) per head of the population per annum. The Canal Zone is a strip of land about 47 miles long extending across the Isthmus of Panama. The rainfall is heavy and the population somewhat scattered.

It must be remarked that Gorgas is referring of course to a sanitary campaign directed against every kind of mosquito.

354. From these few examples which give a fair idea of the cost of anti-mosquito measures in towns and other places, it is possible to make a rough estimate of the probable cost of efficient anti-mosquito work in a large City like Bombay. A general campaign against all kinds of mosquitoes if carried out in Bombay with the thoroughness of the work done at Havana, Rio de Janeiro and Port Said would probably entail an annual expenditure of Rs. 5,00,000 or more. If work were confined to the southern portion of the Island it might be done for Rs. 2,50,000 or 3,00,000 per annum or perhaps for a little less. On the other hand, if instead of attempting to combat malaria by attacking all kinds of mosquitoes collectively, in the hope of including those responsible for the spread of the disease, measures were adopted against the carrier of malaria alone, the expenditure required would be very much reduced.

Section 2.

355. THE COST OF MOSQUITO PREVENTION IN BOMBAY.—It is necessary to go into the question of the cost of efficient anti-mosquito work in Bombay in some detail, in order that a clear idea may be gained of the staff and organization required for such work. If the Municipal Corporation decided to carry out measures against every species of mosquito throughout the whole island in a really thorough manner the work would necessitate the careful inspection of all the premises on the island, occupied or unoccupied, at intervals of a week, or not less than ten days.

356. In the Census Report of 1901 a house was defined as "a building under one undivided roof," but a building having two or more separate roofs connected *inter se* by subsidiary roofs was also classed as a single house. For example, in a case where the roof of a line of servants' quarters was connected with the roof of a stable by a subsidiary roof, covering a passage, the stables and servants' quarters were considered to form one building, or one separate house. Many of the single houses in Bombay are very large and contain many tenements or quarters occupied by separate families. This fact renders a careful inspection of a given number of houses in Bombay a much more difficult matter than the inspection of the same number of "houses" in another country.

357. At the Census of 1906 there were 43,000 houses on the island and at the present time it is probable that there are not less than 45,000 occupied or unoccupied premises in Bombay. This latter number is used therefore as a basis upon which to estimate the cost of a scheme of efficient anti-mosquito work for Bombay, on the assumption that it was proposed to adopt thorough measures

against every species of mosquito. As has already been stated, such a scheme, to be successful, must ensure that every one of the 45,000 "houses" or premises in the City is examined by a trained inspector once every week or ten days. In addition to this house inspection, the inspectors would have to examine the immediate surroundings of each house also, in order that no likely breeding place for mosquitoes escaped attention. Gorgas has given it as his opinion that "An intelligent inspector should readily inspect twenty-five houses a day"; but there is reason to believe that this is rather too high a figure for Bombay. It allows, in a working day of eight hours (excluding office duty and making reports), an average of only twenty minutes to each house, and it is quite impossible to thoroughly examine many of the large premises in the City in as short a time as this.

358. But if we adopt the figure of 25 houses a day as the work to be accomplished by each inspector, one man could inspect at this rate about 600 houses a month, 200 houses every ten days, or 150 every week. Supposing a weekly inspection were decided on for the 45,000 houses in Bombay, a staff of 300 inspectors would be required.

359. The status of these inspectors must also be considered. A trained coolie is as good as anyone for the mere discovery of mosquito larvæ, but trained coolies could not be used as inspectors, and there is the same difficulty in the use of men of a rather superior stamp (*i. e.* "mukadums"), for although well-trained mukadums could do the work efficiently, power of entry to private premises could not be delegated to men below the standing of a sub-inspector. Therefore for a weekly inspection of 45,000 houses *300 sub-inspectors* would be needed.

360. At the present time the Health Department possesses an inspecting staff of 3 chief inspectors, 7 sanitary inspectors, 7 assistant sanitary inspectors and 68 sub-inspectors with another 10 temporary inspectors appointed for anti-mosquito work. It will be seen therefore that the existing staff would allow of little more than a monthly inspection of each house on the island if nearly all the existing inspectors were employed upon this work exclusively.

361. SCHEME I.—*Prevention and destruction of mosquitoes of all kinds throughout the City.*—To carry out efficient inspection of all premises on the island in order to prevent the breeding of mosquitoes would necessitate an increase in the existing staff by about 225 sub-inspectors. As the rate of pay of a sub-inspector in Bombay is Rs. 40 per mensem, this item alone would amount to a sum of Rs. 1,08,000 per annum. And as each of these inspectors would require about three coolies to assist him, and to carry the appliances and material required for discovering and destroying mosquito larvæ this would necessitate an extra staff of about 775 labourers, on a rate of pay not much less than Rs. 12 per month for each man. The cost of these men alone would amount to nearly Rs. 1,11,600 per annum; and the total cost of this extra staff would be Rs. 2,19,600.

362. But it would be necessary to allow for the proper control of the subordinate inspectors also and for this purpose the superior inspecting staff would have to be increased. A full sanitary inspector could not properly supervise the work of more than 10 sub-inspectors, as this would allow him to devote on the average only two to three working days a month to the work of each individual inspector in his charge. Including the 3 chief inspectors, 7 sanitary inspectors and 7 assistant sanitary inspectors, the existing superior inspection staff of the Health Department numbers only 17 all told, excluding the Deputy Health Officers. It would be necessary to nearly double this staff, so as to divide the City into districts containing about 1,500 houses each. On the average the sanitary inspectors of the grade required draw about Rs. 150 per mensem in Bombay, and the increased number would entail an expenditure of nearly 30,000 rupees. Each sanitary inspector would need two peons or puttawallahs which would cost nearly another Rs. 4,600 per annum. It will be seen from these figures that the increased sanitary inspection staff and labour required for efficient anti-mosquito work in Bombay, on the lines of that conducted in Port Said, Ismailia, Rio de Janeiro and other places, would entail an expenditure of about Rs. 2,54,000.

363. It has been found that there are about 5,000 wells on the island and 65 per cent. of the breeding places of malaria-carrying mosquitoes are open wells. A certain number of wells will no doubt be filled up or covered. If we put the number dealt with in this way as 1,000, there still remain 4,000 open wells which require inspection and periodical cleaning. They also need to be stocked with larva-destroying fish. For the purpose of clearing wells of rubbish and floating matter, special gangs of men under good mukadums or sub-inspectors must be employed. It is probable that of the 4,000 unfilled or uncovered wells one-half will require periodical cleansing, probably at least once in three months or oftener—that is to say 8,000 wells must be cleansed each year. A gang of four or five men and a mukadum or sub-inspector could probably cleanse efficiently only about 25 wells a week, so that at this rate six or seven gangs would be required. If sub-inspectors were employed, each gang would cost about Rs. 100 per month apart from "material" and apparatus. The cost of the necessary staff can be put down at about Rs. 8,400. Men would also be wanted for getting a supply of suitable fish; and for stocking wells and other collections of water with them as required. The cost of the staff for this work may be estimated at Rs. 3,000 per annum.

364. The great amount of routine sanitary work rendered necessary by the adoption of such a scheme would require proper control and co-ordination; and this could only be ensured by placing one responsible officer in sole charge of the anti-mosquito measures. This officer, who should be an assistant to the Executive Health Officer, would require to be specially trained or to have had special experience. Ross in his report upon malaria in Mauritius recommends the appointment of a special officer, and states that—

> "The *Malaria Authority* should be an officer who is thoroughly "acquainted with the subject of malaria and also of mosquitoes and their "habits. He should serve under the Director of the Medical and Health "Department..... He will require full facilities for travelling. All his "time should be spent on superintending and organising the general "campaign against malaria, but examination of mosquitoes and other "necessary microscope work will constitute a part of his duty, so that he "will require the necessary microscopes and appliances (this does not mean "a large laboratory.).....Further details of organisation had better be "left to the Malaria and Health Department, but I would earnestly beg "that the holder of the post, while he should be held entirely responsible "for success, should be disturbed as little as possible in his important task."

365. In addition to initiating and watching the progress of the anti-mosquito measures it would be the duty of the special officer to satisfy himself, by a periodical spleen census in different areas, and the careful collection of returns from hospitals and dispensaries, corrected by enquiry and if necessary by microscopical observations, that the anti-mosquito work was giving satisfactory results. Each year it would be necessary for him to prepare a report giving the results of his measurements of malaria and mosquito-borne disease in general and describing in detail the measures taken to combat mosquitoes. In order to properly supervise the work he would require a speedy conveyance to enable him to visit every part of the City at frequent intervals.

366. The salary of such an officer would be about that of the present Assistant Health Officers and the cost of a suitable conveyance would probably amount to Rs. 150 per month. The cost of this special mosquito officer would therefore be about Rs. 13,800 per annum. For the office and laboratory staff required by him, including a clerk and typist, two pattawallas, two assistants of the grade of sub-assistant surgeons, to help in microscopic work on bloods and mosquitoes, and for the necessary laboratory attendants, a further sum of Rs. 3,200 per annum would be required, so that the head office establishment would cost an inclusive sum of Rs. 17,000 per annum.

367. It would soon be found that the effect of more constant inspection necessitated an increase in the number of men employed in cleansing the city, removing accumulations of rubbish, old tins, pots, etc. And for the work of filling in and levelling small pools and hollows and abolishing minor breeding

places of mosquitoes, an increased number of mukadums, coolies and bullock carts would be needed, to work under the control of the sanitary inspectors and the Deputy Health Officers; therefore an allowance must be made for increased expenditure under these heads.

368. If it was found advisable also to carry out the covering of wells and cisterns and the protection of other minor breeding places departmentally, it would be necessary either to increase the existing Public Works establishment or to keep a certain number of carpenters and blacksmiths specially for such work.

369. The estimate for work under these different heads could not be put at less than Rs. 50,000 per annum; but a proportion of this amount would be recoverable.

370. Broadly speaking the increased staff required for really efficient measures of prevention directed against mosquitoes of every kind would cost nearly Rs. 3,32,200 per annum, if that work were confined merely to houses and their surroundings. For the necessary "material" including the laboratory and office equipment, carts and tools, apparatus for examining breeding places, etc., a supply of suitable larvacides (*i.e.*, kerosine, crude petroleum, cresol and carbolic emulsion, etc.), and suitable sprayers for applying them, at least another 1,00,000 of rupees would be required; making a total of about Rs. 4,50,000 per annum.

371. For this sum it should be possible to control the breeding of mosquitoes in the inhabited parts of the island in such a manner as to almost entirely check the mosquito nuisance and prevent the spread of mosquito-borne disease. But if it was decided to still further extend the anti-mosquito measures, so as to include every area of low-lying ground and every pool of water in the north and the north-east of the island, many of which are at a considerable distance from dwelling houses, it would be necessary to increase this estimate proportionately.

372. Briefly the estimated cost of *Scheme I* is as follows:—

	Rs.
225 sub-inspectors at Rs. 40 per mensem	1,08,000
775 labourers at Rs. 12 per month	1,11,600
16 full sanitary inspectors at Rs. 150 each per mensem ...	28,800
32 peons at Rs 12 p. m. each	4,608
Well-cleansing gangs	8,400
Fish gangs	3,000
Head office establishment	17,000
Increased cleaning and departmental work	50,000
Material, larvacides, sprayers, etc.	1,00,000
	4,31,400

373. SCHEME II.—But there is another alternative. If it were decided to limit all measures to those against malaria-carrying mosquitoes alone and to carry out the work only in A., B., C., D. and F. Wards, the staff suggested for special all-mosquito work could be considerably reduced, as it would be necessary to allow for weekly inspections in only a few areas such as the New Dock Works, Railway yards, etc. It would not be possible however, to reduce the well-cleansing gangs, and the staff responsible for stocking wells with fish very greatly. Neither would it be possible to dispense with the special officer and the head office. The employment of one man who could devote his whole time and attention to directing and controlling the work, and who was responsible, in addition, for the preparation of the annual malaria report, is the most essential part of the scheme; and success is not likely to be attained unless such a man is appointed. But it is probable that the work could be accomplished in a satisfactory manner for less than Rs. 1,00,000 per annum. It would be necessary, however, for the Port Trust and Railway Companies to continue their special anti-mosquito work, which should be under the direct control of the Special Malaria Assistant to the Health Officer.

374. For the special measures which would be directed chiefly against *Neocellia stephensi* in Wards A., B., C., D. and E., it would be necessary to allow for an inspection of premises at least once a month. This could be accomplished

by about 50 sub-inspectors (allowing 600 houses to each sub-inspector); four or five full sanitary inspectors could probably control the work of these men; and the subordinate staff required would be about 150 men. The inspectors and men would cost Rs. 54,000.

375. It would be necessary to allow for retaining nearly the full well-cleansing and fish-stocking establishment and the whole of the head office establishment at a cost of Rs. 11,000 and Rs. 17,000 per annum respectively. It would also be necessary to allow about one-quarter or one-third of the full estimate given for material and the cost of special departmental expenditure, which together would amount to about Rs. 40,000 per annum. The total expenditure on this partial scheme would therefore be about Rs. 1,25,000 per annum; but as there are already a certain number of sanitary inspectors working in the area mentioned, the 50 sub-inspectors and 5 full inspectors referred to in this estimate, would include these, and the actual estimate would be reduced much below the figure given above. And if an officer from among the existing staff of assistants to the Executive Health Officer were deputed for full-time anti-malaria work, another item of expenditure would be reduced.

376. The estimated cost of *Scheme II* is as follows:—

	Rs.
Cost of staff for partial work in A., B., C., D. and E. Wards ...	54,000
Well gangs	11,000
Head office	17,000
Material, etc.	40,000
Deduct from this the cost of a certain number of inspectors and labourers already employed	.....

Section 3. 377. COST OF CERTAIN PERMANENT MEASURES OF PREVENTION.—As particulars have been obtained relating to the cost of filling in and protecting certain wells it appears advisable to include them here. The cost of such work would ordinarily fall upon the owners of property unless a special grant were made for the purpose of relieving them of this expense or a portion of it.

378. The cost of filling in a well $4\frac{1}{2}' \times 4\frac{1}{2}'$ was ascertained to be Rs. 25 and another $4\frac{1}{2}' \times 4'$ Rs. 30; two wells about 5 feet in diameter cost to fill in Rs. 55 and Rs. 47 respectively; a larger well cost Rs. 150 to fill in; and as much as Rs. 300 has been estimated as the cost of filling in certain very large wells.

Wells covered with concrete, sheet-iron, boards or wire gauze have cost the following amount for protection.

In the case of wells with contracted openings covered as below :—

No. 1	$3' \times 1\frac{1}{2}'$	Cost Rs.	15.	
No. 2	$2\frac{1}{2}' \times 2\frac{1}{2}'$	„ „	12.	Boards.
No. 3	$3' \times 1\frac{1}{2}'$	„ „	15.	Wire gauze.
No. 4	$3\frac{1}{2}' \times 2'$	„ „	15.	„
No. 5	$2\frac{1}{2}' \times 2'$	„ „	9/8.	„
No. 6	$3' \times 2\frac{3}{4}'$	„ „	12.	„
No. 7	$3\frac{1}{2}' \times 1\frac{1}{2}'$	„ „	10.	Concrete.
No. 8	$3\frac{1}{2}' \times 1\frac{1}{2}'$	„ „	10.	„
No. 9	$3\frac{1}{2}' \times 1\frac{1}{2}'$	„ „	10.	„
No. 10	$3\frac{1}{2}' \times 3\frac{1}{2}'$	„ „	12.	„

Another small well cost Rs. 36 to cover.

The cost of covering two large wells was Rs. 105 and 157 respectively and another rather smaller one cost Rs. 65. Two very large wells covered in a permanent manner with iron joists and sheet iron cost about Rs. 250 or Rs. 300. In the case of four other wells and a fountain the cost of protection has been as follows :—

No. 1	Well	$22' \times 12'$	Cost Rs. 138	Filled in.
No. 2	„	$22' \times 9'\ 3''$	„ „ 45	Do.
No. 3	„	$12' \times 12'$	„ „ 30	Covered with a wooden cover.
No. 4	„	$25' \times 11' \times 18'$	„ „ 148/8	Filled in.
Fountain	„	$16' \times 3'$	„ „ 18	Do.

379. From these figures it would appear that the cost of filling in or efficiently protecting the dangerous house wells so common in the North Fort and Dhobi Talao should not amount to more than from Rs. 15 to Rs. 50 per well. It is probable that nearly all the most dangerous wells in these two sections could be dealt with at cost of Rs. 50,000 and for a total expenditure of about Rs. 1,00,000 two-thirds of the dangerous wells in the south of the island could be prevented from remaining breeding places of *Neocellia stephensi.*

380. In regard to the prevention of dangerous anopheles from breeding in the reservoirs and filter-beds at Malabar Hill and Mazagaon, it may be stated that the cost of efficiently protecting all the ventilators, skylights and exits at Malabar Hill water works should not be very great. It is probably that a sum of less than Rs. 2,000 would amply suffice to meet the cost of the wire gauze required and the work of placing it in position. As regards the provision of an efficient waste water drain along the ravine west of Malabar Hill reservoir, a budget grant sufficient for the estimated expenditure upon this work appears to have been already sanctioned.

381. At Mazagaon, the filter-beds being open, nothing short of covering them will effectively prevent the breeding of mosquitoes. The roofing of the water works at Malabar Hill appears to have cost about Rs. 50,000, but as the reservoirs at Mazagaon are below ground, only the filter-beds being exposed, it is probable that a smaller sum than this would suffice for the work.

There is no data available to show the probable cost of the few small reclamations required at Nepean Sea Road, other parts of the foreshore at Malabar Hill and also at Colaba. But no great sum of money would be needed and the value of the reclaimed land would amply cover the expenditure incurred.

382. In connexion with general mosquito prevention it may be remarked that storm-water entrances and catch-pits, although they have no influence on the spread of malaria, form ideal breeding places for *Culex fatigans;* and just after the monsoon, when they contain water and in the dry weather, when owing to the watering of the streets a little water finds its way into them, swarms of larvæ of *Culex fatigans* are present in many of them. The provision of covers for these entrances, which could be placed in position after the rains, would materially reduce the number of mosquitoes in the City; and although *it is not a measure of anti-malarial sanitation,* it would help to abate a serious nuisance. There are about 6,000 of these storm entrances in the City; and recently a proposal has been made to cover them with an improved lid, at a cost of nearly Rs. 5,00,000.

CHAPTER V.

THE OBSTACLES TO MALARIA PREVENTION IN BOMBAY.

383. In an *ad interim* report published in 1910 it was pointed out that conditions in Bombay were exceedingly favourable for the suppression of malaria by measures directed against the species of mosquito responsible for the spread of the disease. The Island of Bombay is of small size and possessed of no rivers or natural water courses; the population is very large and is concentrated chiefly upon the southern half of the island. This portion of the island, which has an area of about eleven square miles, contains the whole of the City proper with a population of about 700,000 persons; the sea forms its boundary to the south, east and west; and to the north malaria is so little in amount as to be almost negligible. Although the total rainfall is heavy, it nearly all falls in four months and for eight months of the year there is almost no rain. On general grounds therefore there do not appear to be any great obstacles in the way of malaria prevention.

A detailed consideration of the type of breeding places favoured by *Neocellia stephensi*, the principal carrier of malaria in the City, supports the view not only that anopheline reduction is the most suitable measure to use but that as far as natural difficulties are concerned, the work of prevention should be very easy. There appear to be only about 2,000 breeding places in the City, which harbour larvæ of malaria-carrying anopheles at present, and the vast majority are artificial collections of water, such as wells, fountains, and small masonry tanks, which are not in themselves difficult places to deal with. But as we have already seen in the Chapter on the *Legal Aspect of Mosquito Prevention* there are other obstacles to be overcome.

384. The physical obstacles to prevention of malaria in Bombay are so few and insignificant that they would not deter municipalities of one-tenth the size in many other parts of the world, from undertaking the immediate control of malaria (*vide* Durban with a population of 60,000 people, which has spent Rs. 12,00,000 on abolishing certain swamps near the town; and which supports a special mosquito brigade of 2 Europeans and 50 Indians), in spite of the few who might object; but there is a danger that in Bombay ignorance, prejudice and apathy may make the task no easy one.

385. It is a common thing when discussing the problems of sanitation in India to hear people speak of the dense ignorance of the masses, as one of the greatest obstacles to reform. But although this is no doubt true in many cases, a consideration of the facts does not support the view that the dense ignorance of the masses is any great obstacle to the suppression of malaria in Bombay. The ignorance of the masses did not prevent the adoption of a pure water-supply once the educated classes had decided that it was necessary; neither has it prevented the adoption of drainage schemes, street lighting and a host of other improvements that have been introduced into the City from time to time, whenever the educated classes have been convinced of their value; moreover the continued presence of malaria is not due to the habits of the ignorant masses of the population, but to causes for the most part within the control of the educated and wealthy property-owning classes of the community.

386. It is a most significant fact that during the investigation no difficulty was experienced in any part of the City in dealing with uneducated and poor people. Many of these people, especially in places where malaria was prevalent, were keenly interested in the matter; they readily came forward and allowed their fingers to be pricked for the taking of the blood films; and they often brought their children out to be examined. In other cases, when it was pointed out that open wells and other unprotected collections of water were largely responsible for the ill-health of their children or themselves, or for the plague of mosquitoes from which they suffered, many of the householders volunteered the statement that they would gladly have them closed or covered,

but they were only tenants, and they feared that if they asked the landlord to close or cover the well and supply a pump, their rent would be enhanced.

387. But this attitude is not universal. Unfortunately it is among the very classes, who, if they chose to do so, could eradicate autochthonous malaria from the greater part of the City within a year, that opposition has been chiefly met with in the past; and this opposition is likely to prove the greatest obstacle in the future.

388. Early in the investigation very little difficulty was met with in the examination of wells and other possible breeding places on private property, but directly action began to be taken by the municipal authorities against owners of such breeding places, opposition was encountered more frequently; and this opposition usually came from those who were educated, wealthy and influential. In one case, a wealthy and influential house-owner, possessing many houses in one of the best parts of Bombay, threatened to take proceedings for trespass in the event of any of his properties being visited. In another case, the owner of a large mansion, in the grounds of which there were five wells, objected to their being examined and stated that for eight years no municipal inspector had crossed his threshold; but eventually he allowed the examination to proceed after being informed that it was for the purpose of an investigation under Government.

389. Within the past two years also when proceedings have been taken by the Sanitary Authorities against property-owners, with a view to enforcing the adoption of precautions against the breeding of dangerous anopheles, every conceivable excuse has been put forward as a reason for non-compliance. Some well-owners suggested that the covering of wells would be "Disastrous and lead to an outbreak of some pest on account of the accumulated bad gases and stench forcibly confined to wells."

Another idea put forward was that the drains and sewers of the City were leaky and that this was the cause of the trouble. One protest mentioned that—

> "It is generally said and believed that our municipal leaky sewers and "drains allow sewage water to run into wells and pollute them, and hence "mosquito germs are produced or helped to be produced."

390. Another opinion which appears to have received very general acceptance, is voiced thus:—

> "It is, I think, admitted that wells and tanks, besides being of constant "use ordinarily and specially under emergencies, are natural reservoirs or "places for the accumulation of sub-soil water whenever the nature of the "land is watery..... and Bombay land is watery. If they are filled in or "the places of accumulation are done away with, the sub-soil water "must naturally rise to the surface and do much harm and mischief to the "general health."

391. Religious scruples have been put forward again and again as a reason for not protecting a well.

Thus a Hindu gentleman stated regarding a well which he had been asked to cover:—

> "That the well in question is a charitable property, that it is used only "for bathing purposes by persons visiting the neighbouring temple of which "it is an adjunct; that the filling up of the well or even the closing it so as "to shut off the rays of the sun will hurt the religious susceptibilities of the "pious Hindus of the locality."

392. In another case it was put forward by a firm of solicitors as a reason for their clients not complying with an order to cover a well that—

> "The proposed measures are repugnant to eastern ideas and if carried "out would wound the religious susceptibilities of their clients and would "disable them from performing their religious ceremonies and from "washing dead bodies, and would interfere with their religious liberty;

"that the danger against which the steps are prepared to be taken is an "imaginary one, etc."

This letter went on to point out that the cause of malaria in Bombay was the "Excavation of land previously reclaimed by town sweepings" and also stated that—

"The existence of fever is attributable to (1) the existence of sub-soil "water and gases emanating from the ground; (2) the defective construc- "tion of drains; (3) the leaky and choked up condition of the drains which "contaminate wells and places of storage of water; and (4) the use of storm- "water drains for carrying off sullage."

The letter further stated that—

"If the theory of sub-soil water and emanations of gases therefrom is "correct, the measures now proposed would raise the level of the sub-soil "water and further endanger the health of the public."

And it ended by a second appeal on behalf of supposed religious liberty, on the ground that open wells were necessary "As according to their "religious doctrines they cannot use pipe water for the performance of religious "ceremonies; that the water must be exposed to the rays of the sun, which "alone, according to their religious text, keeps the water pure; that the water "drawn from covered wells will not be used for religious purposes; that the wells "would consequently be useless and would become a source of danger to health; "that the measures proposed would not only cause great discontent amongst "occupants of such houses but would be held as tantamount to an interference "with religious liberty which is contrary to law."

393. These views, put forward as serious reasons for allowing known breeding places of dangerous anopheles to go unprotected, represent the present ideas of even the more advanced classes in Bombay, and what is more important from the point of view of malaria-prevention in the City, they represent in many cases the current opinion of property-owners and rate-payers, in whose hands the municipal government is placed. The vast body of the population who are even less enlightened, take but little active interest in questions of sanitation and municipal government.

394. Unfortunately also, the hundreds of medical men in Bombay appear to influence the views of wealthy clients but little. In a Municipal Report of 1902 Dr. Sukhia, a well known Parsi Physician, recommended the covering of wells, in order to protect them from the breeding of mosquitoes; but many hundreds of open wells exist to this day in the houses owned and tenanted by Parsi citizens; and the Parsi community is suffering in consequence. In 1910 a petition signed by about 350 Parsi priests was addressed to the Municipal Commissioner stating that, they could not fill up or even cover their wells, as according to traditional custom they cannot use water for performing religious ceremonies if it is drawn by means of a pump from wells that have been covered up.

395. On the other hand a few of the most enlightened men belonging to the different religious communities in the City, see no great difficulty in arranging a satisfactory solution of the problem.

In reply to a communication from the Executive Health Officer a well known Parsi priest stated as follows:—

"In the Zoroastrian religion great importance is attached to the laws "of health and rules of purity and it has therefore been a common "practice in connection with the wells attached to the sacred places of "Parsis to see that those wells are properly cleaned from time to time and "the water kept in a pure and healthy condition. I am, therefore, of "opinion that the unclean and impure state of the wells referred to by "you has rendered them unfit for human use, much more for a sacred "purpose, which those wells cannot serve until the cause of impurity "has been removed.

"According to the Zoroastrian Scriptures, well water is kept in a "pure condition by its complete exposure to the solar rays, considered as "the best disinfecting and purifying source. Hence it is incumbent that "the well water that is used for daily consecration shall be always entirely "exposed to the Sun. Consequently if it is quite impossible to clean "out impurities from the wells in question, or if it is indispensable for "the sake of public health to cover such wells as a safeguard against the "spread of malaria, then only the suggestion made in the last para. of "your letter about the covering of wire-gauze might be adopted. No "doubt it will be a check to the spread of malaria and partly allow the "solar rays to fall on the well water. But as it is required that some "part of the water consecrated should be poured into the well (from "which it is drawn) at the end of the *Yazishn* and other like ceremonies "and mixed with its source, I am afraid the handpump suggested by you "will not serve the entire purpose. To obviate this difficulty a well-"covered small opening must be made in the wire-gauze. There are, I "suppose, few chances of injurious larvæ and other impurities being "admitted into the well through this opening, as it will always be used "at daytime in the light of the Sun (between 8 and 12 a.m. generally) "and it will be closed in two or three minutes after its opening."

396. And another Parsi priest also recognized as an authority on the Parsi Scriptures expressed his personal opinion as follows :—

"Coming to the subject of your letter, a well is an indispensable requisite "in a Parsee Fire Temple. As according to Parsee Books the Sun is "considered to be a great purifier, it is required that the well must be "exposed to the rays of the Sun. So a well hermetically covered with "wood or metal is prohibited. But one 'hermetically covered with wire-"gauze of very fine mēsh,' as suggested by you, would serve the purpose "and would, I think, serve the Scriptural requirement.

"As to the question of drawing water from such a well, a part of the "three principal ceremonies performed at a Fire Temple is known as "that of *Jor-melavvi* (lit. to unite the Zaothra or ceremonial water with "its source). As we speak of 'dust to dust,' *i. e.*, one born from dust is "in the end reduced to dust, this part of the ceremonial which symbolizes "the circulation of water from the earth to the air and from the air to "the earth requires what we may, on a similar analogy, speak of as the "transference of 'water to water.' It requires that a part of the water "drawn for ceremonial purposes from the well must be in the end returned "to its source—the well. So, the provision of the air-pump, will not, I "am afraid, meet all the requirements. I would therefore suggest that "in addition to the hand-pump, a small close-fitting opening, also made "of wire-gauze of fine mesh, may be provided. For ordinary purposes the "hand-pump may be used, but for the exceptional occasions, when the "water is to be drawn for ceremonial purposes, and for the above-named "*Jor-melavvi* ritual, the opening may be used. As the water for "ceremonial purposes is required during the day time only, this provision "will not permit of the mosquitoes getting in, which generally occurs at "night. Even during the day, it will not require a frequent opening."

397. The views quoted above show that there need be no real difficulty in satisfactorily protecting the wells in Parsi houses, provided the house-owners are willing to meet the authorities in the matter.

398. In the case of Hindus there may be some slight difficulty; but if the leading citizens of this important community wish to do so, they can easily arrange a satisfactory solution of the problem. At present time there appear to be certain Hindu temples in the City that depend for their water-supply upon the water mains; and information has been received that, in a Jain temple the well is provided with a cover and a pump is regularly used for raising water.

399. In regard to the opinion commonly expressed by Parsis and echoed by Hindus, that a well should be open to the rays of the sun, it may be pointed

out that the vast majority of the most dangerous wells in the City are so situated that sun-light cannot penetrate to them; and except in the case of the Parsis, the view appears to be based rather upon some vague idea that air and day-light will purfiy water, than on any strict religious grounds. It is a common experience to find that Indian servants employed in large residential flats in the City, which usually have many closed cisterns upon their terrace roofs, persist in opening the lids of the cisterns, in order that the sun may gain access to the water.

400. As regards the suggestion that the filling in of tanks and wells may cause a rise in the level of the subsoil water, or that the covering of wells may interfere with their ventilation, it may be pointed out that—

(1) The filling in of all the tanks and wells on the island would not affect the subsoil water level to any appreciable extent. The amount of water present in the wells and tanks represents only a fractional proportion of that present in the soil; and the water level of wells or tanks is usually much below the level of the subsoil water. The average rainfall in Bombay is close upon 72 inches or nearly 6 feet of rain per annum which is equivalent to a fall of 37·5 gallons of water upon every square foot of the surface of the land. Much of this enormous volume of water drains away into the sea, but a considerable amount which would otherwise drain away goes into the wells and tanks and raises their water level considerably; and the existence of these open wells and tanks helps to maintain the subsoil water at a higher level than it would otherwise reach.

(2) As regards the supposed necessity for ventilating wells, it may be pointed out that the fact that a well is quite open and uncovered does not necessarily ensure its ventilation. The only way to ventilate many wells is by drawing out a considerable volume of water from them, and a well entirely covered may be better ventilated, if water is being continually pumped out from it, than a well the mouth of which is quite open. Other things being equal the water from a well that is entirely covered will be cleaner and much purer than that from an open well, especially one in the midst of a populous city, exposed to dust and all sorts of contamination. At the present time very few of the wells in Bombay supply water that is fit for potable use; and the covering of the majority of these wells would be a great sanitary improvement even apart from the question of malaria prevention.

CHAPTER VI.

THE PLACE OF QUININE IN THE PREVENTION OF MALARIA IN BOMBAY.

401. When considering the problem of malaria prevention in Bombay it is unnecessary to discuss the relative merits of quinine prophylaxis and anopheline reduction because the facts described in detail in the chapters dealing with "Malaria in Bombay" and "the Mosquitoes of Bombay" lead to the conclusion that anopheline reduction is not only possible but comparatively easy of accomplishment as far as the absence of physical obstacles in the city is concerned. Moreover, as has been pointed out in a previous report, the general conditions present are so favourable to the success of anopheline prevention that the complete eradication of autochthonous malaria should be aimed at rather than the mere mitigation of the disease.

402. This being so, the place of quinine in any scheme of malaria prevention for Bombay should be a subordinate one. But it must be made clear that this statement is in no sense a generalization. It relates only to the Bombay City; it is a conclusion arrived at as the result of careful investigation; it is based upon the assumption that the end to be achieved is not the mere palliation of malaria but the complete eradication of local sources of infection; and should any scheme aiming at mitigation of malaria rather than its complete control be finally adopted in the city, the question of prevention by quinine treatment would require further consideration.

403. Shortly after the commencement of the investigation Captain A. G. McKendrick, I. M. S., who was then in charge of the work, proposed that a distribution of quinine should be undertaken in certain malarious areas in order to effect an immediate mitigation of the disease and in the hope of preventing a recurrence of epidemic malaria in the following autumn. The Municipal Commissioner supported his proposals, and as a result the Municipality made a special budget grant to cover the cost of the measure. Two medical men and ten compounders were placed in charge of the work of distribution which was commenced in April 1909. At first it was confined to the treatment of children shewing splenic enlargement, but as a result of blood examinations which shewed that children without enlarged spleen, and adults also, harboured malarial parasites in almost as great a proportion as children with spleen, after July 1909, treatment was extended to all who were willing; and by the end of August between 4,000 and 5,000 people were in receipt of the remedy.

404. Each compounder was given a certain area to cover and was supposed to visit each house about three times a week. The use of sugar-coated tablets was at first decided on, but there was some little delay in obtaining a supply and for about ten weeks coated pills were used. The pills proved to be unsatisfactory as it was found that many of the children did not swallow them; in some houses they were simply put on one side and in other cases they were thrown away; but when the sugar-coated tablets arrived they appeared to be much more acceptable than the pills, and they were taken readily both by the small children and adults.

405. The following table gives particulars of the amount of quinine distributed :—

			Grains of quinine.	Total grains of quinine.
April	1,000	5 grains	5,000	= 15,000
	5,000	2 „	10,000	
May	2,000	5 „	10,000	= 46,000
	18,000	2 „	36,000	
June	8,000	5 „	40,000	= 105,200
	32,600	2 „	65,200	

				Grains of quinine.	Total grains of quinine.
July	16,000	5	grains.	80,000	= 140,000
	30,000	2	„	60,000	
August	52,000	5	„	260,000	= 320,000
	30,000	2	„	60,000	
September	34,000	5	„	170,000	= 218,000
	24,000	2	„	48,000	
October	23,500	5	„	117,500	= 197,500
	40,000	2	„	80,000	
November	42,000	5	„	210,000	= 270,000
	30,000	2	„	60,000	
December	44,000	5	„	220,000	= 268,000
	24,000	2	„	48,000	
Total	222,000	5	grains	1,112,500	1,579,700
	233,000	2	„	467,200	

406. The distribution was confined to portions of the North Fort, Esplanade and Mándvi, an area which adjoins the New Dock Works and which had suffered seriously from malaria for several years. In addition to the quinine distribution by the Municipality the Port Trust distributed 780 rupees worth of quinine in 1909 and 1,748 rupees worth in 1910 and the B. B. & C. I. Railway Company also expended Rs. 268 in sugar-coated tablets for their employés at Carnac Bunder Goods Yard during 1909.

407. Although it is difficult to give exact figures to shew the value of this distribution, the absence of any serious amount of fever among the population among whom the distribution was being made in spite of the fact that more than one-third were infected with parasites of malaria at the commencement is most significant. In one area the spleen rate dropped steadily from 54 per cent. in July to 33 per cent. in October and 29 per cent. in December 1909. And there is little question that the improvement in the area near the docks, recorded in the chapter on the *Recent Results of Malaria Prevention*, was in part due to this free use of quinine. Many cases shewed a remarkable improvement under treatment. One man got special leave from his work in order to exhibit himself, being very proud that he had got rid of an enlargement of the spleen extending to below his *umbilicus*.

408. The general conclusion arrived at whilst watching this distribution was that it was an eminently practical measure for the mitigation of malaria in areas seriously affected; and that, provided a palatable and efficient form of quinine was employed, it was exceedingly well received by the people. The most marked effect of the measure was not so much the reduction of cases of infection as the alteration in character of the infections, the parasites being reduced in numbers, with the result that few cases of actual sickness occurred among those under treatment.

409. The best results were observed among the people who were induced to take quinine by persuasion only. In the case of a chawl in which the residents were all municipal employés (sweepers) it was found that the compounder was endeavouring to insist upon people taking quinine; but pressure of this kind defeated its object, for people merely accepted the drug and either kept it or threw it away. On the other hand, in cases where persuasion was relied upon entirely, it frequently happened that people who at first refused the remedy subsequently requested to be allowed to have it.

410. The distribution was discontinued in December 1909 and it was not resorted to during 1910. But in the course of a number of visits paid to the area of distribution during the latter year numerous enquiries were received from residents as to whether the quinine tablets were again to be distributed or not, and the general opinion expressed by the people in that area was to the effect that they had derived great benefit from the measure.

411. In addition to the distribution of quinine carried out by the Municipality, the B. B. & C. I. Railway Company and the Port Trust, the P. & O. Company distributed quinine amongst their employés also. In 1910

24,000 pills were distributed among the crew of their vessels leaving Bombay after July. The results appear to have been very satisfactory, as very few cases of malaria occurred among those in receipt of the pills, although the previous year on boat after boat from 80 to 100 of the crew had been attacked.

412. *The sale of Quinine in palatable form.*—During 1910 a small experiment was carried out in order to determine the possibility of popularizing quinine by putting it up in a palatable form in small quantities and placing it on sale at tea shops and with small vendors to whom a discount or commission was allowed. For this purpose a number of 5-grain sugar-coated tablets of quinine were obtained, packed in glass tubes, each containing 12 tablets. All the tubes were labelled in English and in one of the vernaculars, some in Gujaráti, some in Maráthi and others in Urdu. Directions in English and one or other of the vernaculars were enclosed. The experimental price was fixed at annas 2½ per tube and a commission of ½ an anna per tube was allowed to each vendor. Those who agreed to sell were supplied with a large placard printed in the vernacular announcing the fact that sugar-coated quinine tablets, for the treatment of malaria fever and spleen, were on sale there; they were given 12 or more tubes of tablets, and on a subsequent visit they paid for any they might have sold at the rate of Rs. 1-8 per dozen.

413. The experiment was only carried out at the end of 1910 and altogether 28 vendors were engaged. The following table gives particulars of the class of seller, the locality and the number of tubes disposed of:—

No.	Class of seller.	Locality.	No. of tubes.
1	Iráni tea shop	South Fort	24
2	Do.	Do.	24
3	Hindu tea shop	Do.	12
4	Iráni tea shop	North Fort	7
5	Do.	Do.	28
6	Ghándi	Mint Road	31
7	Iráni tea shop	Do.	20
8	Do.	Frere Road	24
9	Do.	Do.	31
10	Mahomedan tea shop	Do.	48
11	Hindu tea shop	Do.	151
12	Iráni tea shop	Do.	84
13	Hindu tea shop	Do.	76
14	Iráni tea shop	Do.	6
15	Do.	Do.	12
16	Mahomedan tea shop	Do.	61
17	Iráni tea shop	Dhobi Taláo	19
18	Grocer	Do.	2
19	Ghándi	Do.	96
20	Do.	Do.	12
21	Iráni	Do.	17
22	Iráni tea shop	Esplanade Road	28
23	Do.	Do.	12
24	Hindu tea shop	Do.	3
25	Muccadum	Improvement Trust chawls ...	83
26	Ghándi	Carnac Bridge	132
27	Do.	Parel	12
28	Medical man	Dádar	193
	Sold in office to different individuals ...	.....	44
		Total ...	1,292

414. It will be seen from this table that a total of 1,248 tubes was sold by 28 vendors in less than six months, an average of 44·5 tubes per vendor. Each tube contained twelve 5-grain tablets or 60 grains of quinine, and the total amount sold was equivalent to nearly 180 ounces of the drug. On the average therefore each of the 28 vendors sold over 6 ounces of quinine salt. It would be reasonable to assume that they would sell at least an average of

another 4 ounces during the remainder of the year, so that 10 ounces may be estimated as the average amount such small vendors would dispose of each year. As will be seen most of the vendors supplied were the owners of tea shops, and in one of these tea shops 151 tubes were sold or over 20 ounces of quinine. Only three indigenous drug-sellers were supplied but one of them was successful in disposing of 132 tubes or over 18 ounces of the drug. In one case the muccadum in charge of a chawl sold as many as 83 tubes. This man who was a Mussulmán was anxious to obtain 400 tubes to send to Mecca but the conditions of the experiment did not allow of its being supplied to him.

415. The conclusion to be drawn from this small experiment is that the supply of a palatable form of quinine—preferably sugar-coated tablets put up conveniently and attractively in small quantities at a price within the reach of the masses of the population—is likely to meet with a considerable demand, and if it is supplied to vendors at a price which will allow them a fair profit as an inducement for pushing its sale, the results both as regards the popularization of the remedy and the mitigation of malaria are likely to be very satisfactory.

416. The use of sugar-coated tablets appears to be an important factor in conducing to the popularization of the drug. A missionary who was recently on tour in the Konkan was given a small supply of the tubes to distribute and asked to express his opinion as to their probable reception if placed upon sale. In a recent letter referring to this matter he states :—

> "One thing which has been commented on with peculiar satisfaction "is the advantage of the sugar-coated tablet form over the quinine powder "(or crystals). One Police Officer, not quite fully conversant with English "..... said that the 'sourness' (meaning 'bitterness') of the "quinine in packets prevented his men from using the latter although "supplied to them free, but that these tablets could be taken readily."

417. A point that was remarked upon by some of the vendors was that there was no maker's name upon the tubes supplied; but this is a matter that can easily be arranged. The size of the tablets was objected to by some, especially when they required the remedy for the use of children, and it is probable that a smaller tablet about the size of those used in Italy would be more suitable. The Italian tablets are sugar-coated and contain 0·20 of a gramme (about $3\frac{1}{3}$ grains) of quinine. Tablets of either bi-sulphate or bi-hydrochloride of quinine are on sale in that country at every shop licensed to sell salt or tobacco.

418. On the score of cheapness the bi-sulphate of quinine is especially suitable for India, and there is no reason to believe that it is much inferior to the other salts of quinine in the treatment of the vast majority of cases of malaria. But to make quinine a popular remedy it must be administered in a palatable form, and although sugar-coated tablets may not be quite so effective as solutions of quinine, the powdered drug, or even uncoated tablets, there is little question that they are very much better than no quinine at all; and the result of practical experiment has been to shew that when dealing with large numbers of people among whom persuasion and not compulsion has to be relied upon, sugar-coated tablets of quinine are more generally effective than any other form of the drug.

419. A considerable amount of quinine in this form is already consumed in Bombay not only among European and educated Indians but among certain of the poorer classes. Usually sugar-coated tabloids containing 2 grains appear to be used. They are sold in the bázár for about Re. 1-4 a bottle of 100. But there are many people who do not know of them or cannot afford to purchase as large a quantity as 100. Among the better class of coolies many do not care to attend hospitals or dispensaries for gratuitous treatment, but they will readily purchase medicine that they think is really useful, and it is these people who will welcome the sale of quinine tablets.

420. *Treatment of cases of Malaria in Bombay.*—It is necessary to refer to the treatment of cases of malaria in Bombay, because enquiry has shewn that there is good reason to believe that the treatment received by sufferers from malaria in the city is not always efficient. It has been found that many people

have a great prejudice against the use of quinine, and prefer to use some other remedy; others make use of quinine, but in doses so ridiculously small as to be almost of no value; and there are, as has been mentioned elsewhere, a considerable number who use neither quinine nor any other remedy when attacked by intermittent fever.

421. Unfortunately many medical men appear to share the common prejudice against the use of adequate doses of quinine, and prescribe doses of two or three grains twice or three times daily. As a result the sufferer from malaria derives little or no benefit from the treatment, and both patient and physician become confirmed in their belief that quinine is of little value, or that it is unsuited to the constitution of Indians.

422. As it is a matter of importance to determine the minimum amount of quinine that will cure ordinary cases of malarial fever, the majority of which are mild intermittents, advantage was taken of the fact that, during the investigation in the south of the island, a considerable number of people presented themselves at the office of the enquiry and asked for treatment. Gratuitous treatment was given to a number of cases in this way. The blood of the patient being first examined, a supply of medicine sufficient for 3 or 4 days' treatment was given to him, and he was instructed to return for a further supply of medicine and to report progress as soon as the medicine was exhausted. The preparation of quinine used was the bisulphate in the form of sugar-coated tablets, 5 grains in each.

423. The routine treatment adopted for adults was four 5-grain tablets a day for the first 3 or 4 days. At the end of this time they had to return for a further supply of medicine. On the second visit they were told to continue with 3 tablets a day for three days and then 2 tablets a day for three days, after which they had to take 1 tablet a day for a month.

424. The mode of treatment gave excellent results in all the cases of malaria who visited the office. In no case did the 20 grains of quinine daily fail to check an intermittent. It must be pointed out, however, that the class of case met with was not of the severe kind so often seen in hospitals. Serious attacks of malaria immediately endangering the life of the patient form only a very small proportion of the total cases of malaria, and the problem to be solved is not so much the treatment of this class of cases as of the mild but persistent intermittents.

425. In the treatment referred to above no great stress was laid upon particular dosage, patients being told to take either 2 tablets twice a day or one tablet four times a day as they felt disposed, the only thing that was impressed upon them was that they *must* take the full four tablets daily until the fever had ceased to return on the expected day.

426. As regards recurrences or relapses it may be pointed out that in no case did a patient get a relapse while under treatment, but some who neglected to continue the treatment after the first cessation of fever had relapses after an interval of from ten days to three weeks. No very young children were treated, but in the case of several, aged about 10 or 12 years, 15 grains a day was given in place of 20 grains for the first three or four days, thereafter 10 grains for about a week and then 5 grains daily for a month.

427. A point in connexion with the treatment of malaria which frequently arouses discussion is the form the remedy should take. It is frequently laid down that quinine should not be administered in the form of pills or tablets but in solution or powder; and experience in regard to many serious hospital cases leads physicians to insist on a dosage of from 30 to 50 or more grains of quinine a day. Both these rules are excellent ones for the treatment of serious cases of malaria, but insistence upon them in the case of the vast majority of mild intermittents is a mistake, because it nauseates patients needlessly with the taste of the drug and alarms them by the cinchonism induced.

428. From the observations described above it appears reasonable to assume that for the treatment of mild intermittent malaria, which forms the majority of the cases of the disease met with in Bombay, 20 grains of quinine

a day for 3 or 4 days is sufficient to check the paroxysms, and that the majority of relapses may be prevented by continuing with a small daily dose of quinine (about 5 grains) for a month or more.

429. Young children and even infants appear to bear quinine proportionately much better than adults. A child of 5 years of age can easily bear a dose of 5 grains of quinine repeated twice a day, and it is doubtful if much less than a 2-grain dose is of any value in the treatment of infantile malaria. Infants of under a year can bear the latter amount of quinine easily and children of two or three years old, if suffering from chronic malaria and enlarged spleen, often improve under a daily dose of 5 grains, increased to 10 when they get fever.

430. Finally, as regards the form the preparation should take, it may be pointed out that although quinine solution is undoubtedly the best way in which to administer quinine to individual cases, sugar-coated tablets are so easily taken even by small children that they offer a very great advantage when dealing with malaria-infected populations. From the point of view of the prevention of malaria it is of more importance that, the many thousands of mild cases should obtain a form of treatment which they will accept readily and which will be of real service to them, than that, they should be discouraged from making use of a remedy, by insistence upon certain ideal conditions as regards its form and dose, which are only of great importance in serious cases of the disease.

CHAPTER VII.

SOME REASONS WHICH MAKE IT IMPERATIVE THAT THE CITY OF BOMBAY SHOULD UNDERTAKE THE ERADICATION OF MALARIA.

431. Now-a-days the existence of a preventible disease in an important city cannot be ignored and it has become the custom in large towns in the tropics to carry out certain measures of anti-malarial sanitation as a matter of routine. It is generally considered that such measures should be proportionate to the prevalence and intensity of the disease, and that when malaria is comparatively mild there is little need for drastic methods and heavy expenditure, but if epidemics occur greater efforts must be made and increased expenditure incurred.

432. Approaching the question of malaria prevention in Bombay from this standpoint, it might be argued that, because malaria is endemic in Bombay, it is necessary that measures for the prevention of the disease should be adopted. It might be urged also that because the deaths from malaria numbered many hundreds, the cases of disease many thousands and the money loss occasioned to the City amounted to twelve or more lakhs of rupees per annum, it was reasonable to spend a considerable sum in an endeavour to reduce these figures.

433. But there is a more important reason for adopting adequate measures for the prevention of malaria in Bombay than considerations such as these; and the possibility, not only of diminishing the amount of malaria in the island, *but of totally eradicating the local sources of infection* from the City, makes it imperative that adequate measures for attaining this end should be adopted without delay.

434. If evidence is wanted in support of this statement it is only necessary to point to the areas in the centre and north of the island, which are at present almost free from malaria. A., B. and C. Wards are probably 80 times as malarious as Mahim, Worli and Sion, but there is no valid reason why the former area should not be rendered as free of malaria as the latter; and it should be possible to accomplish this in a very short time, and with the expenditure of a comparatively small amount of money.

435. Many people are already familiar with the records of the anti-malaria work that has been accomplished at Panama, Ismailia, Havana and other places, but a repetition of some of the figures supplied by the officers responsible for the work may be of interest.

436. *Hongkong.*—The anti-malarial measures adopted in Hongkong appear to have been only partial ones. Dr. Clark, the Medical Officer of Health for Hongkong, gives the following figures regarding the admissions to hospitals from malaria and the mortality from this cause. The improvement recorded is ascribed to the anti-malaria measures that have been adopted in the City.

Admissions to Hospitals.

Year.	Government Civil Hospital.	Tung Wah Hospital.
1896	516	No record.
1897	450	1,021
1898	344	865
1899	475	780
1900	679	1,220
1901	787	1,294
1902	349	752
1903	347	568
1904	221	433
1905	266	419

The admission of malaria among the Police.

Year.	Total average number of Police.	Total admission of Malaria.	Ratio per 1,000.
1896	631	203	301
1897	630	160	254
1898	630	121	192
1899	770	639	310
1900	929	390	419
1901	920	407	442
1902	919	176	191
1903	921	167	181
1904	993	107	107
1905	1,018	127	124

Deaths from malaria in Hongkong.

Year.	Deaths in the City.	Total in Colony.
1896	290	533
1897	302	554
1898	280	530
1899	218	546
1900	242	555
1901	281	574
1902	189	425
1903	152	300
1904	90	301
1905	87	287

Dr. Clark states regarding these figures—

"The rapid fall in the number of deaths from malaria within the "city during the second quinquennium is most gratifying, for it is "naturally here that most of the anti-mosquito work has been carried "out . . . . . "

437. *Rio de Janeiro.*—Mr. M. R. Pestana, the author of "*Comment on assainit un pays,*" gives the following figures as the recorded mortality from malaria at Rio de Janeiro, before the commencement of the anti-mosquito work there:—

1900 ... 1,019 deaths from malaria.
1901 ... 932 „ „ „
1902 ... 1,217 „ „ „

Anti-mosquito measures were commenced in 1903 and the recorded mortality has steadily diminished since that year.

1903 ... 772 deaths from malaria.
1904 ... 433 „ „ „
1905 ... 295 „ „ „
1906 ... 266 „ „ „
1907 ... 239 „ „ „

The author adds that owing to the fact that the city possesses many large and modern hospitals which are greatly resorted to by patients from the interior, many of the deaths from malaria shown as occurring in Rio de Janeiro are of cases that did not contract their infection in the city.

438. *Havana.*—In the "Sanidad y Beneficencia" Dr. J. Le Roy y Cassa gives the following figures which show the mortality from malaria before and after the anti-mosquito measures commenced by Gorgas early in 1901, and continued since then.

Years.	Total mortality.	Malaria mortality.	Co-efficient of malaria mortality.
1896	11,762	450	1·95
1897	18,135	811	3·46
1898	21,252	1,907	8·00
1899	8,153	909	3·76
1900	6,102	325	1·30
1901	5,720	151	0·55
1902	5,832	77	0·29
1903	5,465	51	0·19
1904	5,583	44	0·16
1905	5,832	32	0·11
1906	6,144	26	0·08
1907	6,708	23	0·08
1908	5,994	19	0·06
1909	5,988	6	0·01

439. *Ismailia.*—The following table gives the record of cases of malaria at Ismailia since 1877 as given by Dr. Pressat. Malaria has disappeared since the introduction of anti-malaria sanitation :—

Years.	Cases.	Years.	Cases.
1877 ...	300	1893 ..	1,750
1878 ..	400	1894 ...	1,000
1879 ...	500	1895 ..	1,350
1880 ..	400	1896 ...	1,150
1881 ..	450	1897 ..	2,089
1882 ..	480	1898 ..	1,545
1883 .	550	1899 ...	1,545
1884 ...	900	1900 ...	2,284
1885 ..	2,000	1901 .	1,990
1886 ..	2,300	1902 * ...	1,551
1887 ..	1,800	1903 ...	214
1888. .	1,400	1904 ..	90
1889 ...	1,450	1905 ...	37
1890 ..	1,900	1906 ..	No fresh cases.
1891 ..	2,590	1907 ..	No fresh cases.
1892 ..	2,050	1908 ...	No malaria contracted in Ismailia.

* Anti-malaria work was begun in 1902.

440. *Panama.*—Since the commencement of work at Panama there has been an extraordinary reduction both in the total amount of sickness and mortality, and that recorded from malaria. Gorgas describing the present conditions, says :

"Our death-rate for the total population on the Zone has fallen from "a maximum of 67·72 per 1,000 in July 1906 to 21·52 in December 1909. "The rate for 1905 was 49·94; 1906—48·37; 1907—33·63; 1908—24·83; "1909—18·19 (per thousand). The death-rate among employees from "disease has fallen from a maximum of 62·15 in July 1906 to 10·13 in "December 1909."

Referring specially to the results of the special work against malaria Gorgas says :

"It has reduced the deaths from malaria in the total population from "a maximum of 16·21 per 1,000 in July 1906 to 2·58 per 1,000 in "December 1909. Among employees it has reduced the deaths from "malaria from a maximum of 11·59 per 1,000 in November 1906 to 1·23 "per 1,000 in December 1909. The admission rate among employees has "fallen from a maximum of 1,263 per 1,000 in July 1906 to 191 per "1,000 in December 1909. The admission rate per thousand among "employees has been as follows :—1914—125;—1905—514; 1906—821; "1907—424; 1908—282; 1909—215."

Mr. J. A. LePrince, C.E.A.M., Chief Sanitary Inspector, Panama Canal Zone, states that—

"From the 31st October 1909 to 1st January 1910 during the period "of heaviest rainfall, only 3·26 per cent. of the force (labourers) were "hospital malaria cases."

441. *Wilhelmshaven.*—It is recorded that in 1896 during the construction of the harbour at Wilhelmshaven, a fearful epidemic of malaria occurred, which affected both the workmen, the crews belonging to the shipping and the residents in the vicinity. At this time little was known of the possibility of preventing malaria. But during the recent enlargement of the harbour works, special precautions were adopted from the commencement and as a result there has been no outbreak of the disease.

442. The result of the preventive work that has been carried out at Panama and Wilhelmshaven shows that even among aggregations of labourers engaged upon construction work in malarious areas, the adoption of adequate precautions is sufficient to neutralize the risk of epidemic outbreaks of malaria, to which these temporary collections of labourers are specially liable.

443. Before concluding the chapter it may be as well to draw attention to an objection that may possibly be raised to the carrying out of anti-anopheline measures in Bombay, on the ground that such measures have failed at Mian Mir, a station in India in which, as is well known, anti-malaria measures were undertaken some years ago.

444. Mian Mir (now called Lahore Cantonment) is a military station in the Punjab, possessed of a population of about 16,000, and covering an area of about 8 square miles. The country in which it is situated is exceedingly flat, and owing to the impervious nature of the soil the area is an exceedingly difficult one to drain. In a description of Mian Mir it is stated that:—

"After one or two hours of continuous rain the appearance of the "cantonment is changed from that of an arid plain to that of a district in "flood. Broad expanses of water, often a quarter of a mile in extent, "cover the plain on every side and the inhabitants of the follower's huts "on some of the comparatively lowlying parts are literally flooded out. "The majority of these large expanses of water dry up in the hot sun in "three or four days, but numerous small deeper pools are left which, lasting "for the week or ten days, form excellent breeding grounds of anopheles "mosquitoes."

Unfortunately the anopheles mosquitoes responsible for the spread of malaria in Mian Mir readily breed in the pools of water that form in and about the station during the rainy season, and as these pools exist in every direction out in the open country far beyond the limits of the Cantonment, it becomes an almost impossible task to control the breeding of dangerous anopheles there; and although irrigation has been abolished and a considerable amount of preventive work has been attempted, the results have not been satisfactory.

445. To those who do not realize that malaria is a disease almost entirely dependent upon local conditions, the fact, that anti-anopheline measures have failed in one place, may seem an argument against their adoption in another. But such a view is not a reasonable one.

446. A brief comparison of the conditions relating to malaria in Mian Mir, with those present in Bombay, is given below:—

		Mian Mir.	Bombay.
1.	Size ...	Cantonment area 8 square miles .	Total area of Island 22 square miles.
2.	Population ...	16,000	977,288.
3.	Municipal income .	Rs. 60,000	Rs. 1,20,00,000.
4.	*Malarious area* ...	Whole inhabited portion of Cantonment.	Less than half the Island.
5.	Breeding places of malaria-carrying anophelines.	Natural in character. Chiefly pools of rain water in and around Cantonment. Number unknown, and probably almost unlimited at certain times of the year.	About 2,000. Almost all artificial in character. Chiefly wells, masonry tanks, iron cisterns and a few pools and minor collections of water. The vast majority of the pools that exist are harmless from the point of view of malaria.
6.	Limits of dangerous area.	Pools may occur not only in the Cantonment but in the dangerous zone of flat land around it, which extends for miles. E. H. Ross has shown that even at Ismailia, which is surrounded by desert, a few mosquitoes enter the town from small breeding places a mile away, near a part of the fresh water canal. If this is the case at Ismailia, what must be the condition at Mian Mir which, in the rainy season, is surrounded with breeding places ? To prevent malaria at Mian Mir it would probably be necessary to control an area as large as the whole of Bombay Island.	There is no dangerous zone around the City. The sea surrounds it on three sides, and malaria is negligible in the north of the Island. In the north of the Island also very few breeding places harbour malaria carrying anophelines. To free Bombay from the greater part of the malaria present there, it is only necessary to control an area of about 10 square miles.

This comparison shows that conditions are much more favourable to successful anopheline reduction in Bombay than at Mian Mir.

CHAPTER VIII.

FINAL CONCLUSIONS REGARDING MALARIA PREVENTION IN BOMBAY.

447. In the preceding Chapters the prevalence and distribution of malaria on the Island of Bombay have been discussed; the causes responsible for the existence of autochthonous malaria, in other words, the species of anopheles mosquito which spreads the disease, have been described, their breeding places have been examined, and their general distribution in the City studied; and the factors which tend to produce fluctuations in the intensity of malaria from year to year have been considered. The measures which have been adopted from time to time with a view of mitigating the disease have been described; and the cost of such measures and the difficulties to be encountered in putting them into practice have been reviewed at some length; and it only remains to summarise as clearly as possible the final conclusions that have been arrived at regarding the problem of malaria prevention in Bombay.

448. In the chapter on "Malaria in Bombay" it was shewn that, though not nearly as prevalent in Bombay generally as in many parts of India, the disease is present in every part of the Island; but while infections are uncommon and as a rule exceedingly mild in the north they are prevalent and severe in the south; and although malaria does not appear to be directly responsible for a very heavy mortality, probably under a thousand deaths per annum in ordinary years, there is reason to suppose that it gives rise to a great amount of sickness, from 60 to 75 per cent. of all fever cases being due to the disease. The resulting loss to the City amounts, on the average, to a sum of not less than Rs. 12,00,000 to Rs. 13,00,000 per annum.

449. The many thousand sufferers from malaria are drawn from every class of the population, the rich as well as the poor; but of the different communities the Párs appear to shew proportionately the greatest evidence of malaria infection; and the results of this are reflected in the high percentage of enlarged spleens among Pársi children, the relatively larger spleens among these children in certain areas, and the general low vitality of the race, indicated by their failure to shew a natural increase, no great excess of births over deaths taking place among them from year to year.

450. In the chapter on "Mosquitoes" it was proved that the commonest *anopheles* in the island (*N. rossi*) plays no part in the spread of the disease; but Major Liston's discovery of the part played by *N. stephensi* in the spread of malaria was confirmed; and it was shewn that the distribution of this mosquito and its breeding places in the City coincided in a remarkable manner with that of the relative prevalence and intensity of malaria.

451. As regards the malaria epidemic of 1908, the occurrence of which suggested the need for an investigation, it has been shewn that, the cause of the outbreak was neither the importation of the disease nor a wave of malaria passing over India, but the previous existence of many hundreds of breeding places of *Neocellia stephensi* in the City, each of which formed a centre of infection. In this way many thousand people became infected, and from time to time, as local conditions were favourable to its spread, malaria increased both in prevalence and intensity. In 1906 and 1907 there were undoubtedly very many thousand infected persons in A., B. and C. Wards, and the sudden rise in the prices of food in the latter half of 1907 helped to intensify existing infections, pre-dispose to relapses and generally favour the spread of malaria. In 1908, in spite of a short rainfall, the distribution of the rain and general climatic conditions appear to have been favourable to the production of large numbers of *N. stephensi*, and this, occurring at a time when very large numbers of people in the City were already infected with malaria, caused a great intensification of the disease, which was enhanced by the further rise in the prices of food in September of that year.

452. The observations relating to the malaria-carrying anophelines present on the island shew that, though the Municipality was justified in attempting to combat malaria by measures directed against mosquitoes, until Major Liston's discovery of the fact that *N. stephensi* was the carrier responsible for the spread of most of the infection, the attack could not be concentrated upon the most dangerous agent of transmission; and in the absence of proper legal powers, sufficiently generous financial assistance, and the co-operation of the wealthy and educated classes of the community, the efforts of the sanitary authorities could effect only a slight mitigation of the disease.

453. In a previous report it was pointed out that, in India generally the prevention of malaria was usually a question of mitigation of the disease, but that in Bombay there was good reason to believe that the adoption of adequate measures would bring about the complete eradication of autochthonous malaria from the greater part of the island. It is generally recognized that the existence of endemic malaria is the prime cause of epidemic malaria, and so long as endemic malaria remains uncontrolled, epidemics are likely to occur, whenever conditions become favourable for such manifestation of the disease.

454. To prevent epidemic malaria therefore it is necessary to control endemic malaria; and the eradication of endemic malaria from Bombay must be aimed at (1) because as far as natural obstacles are concerned it should be easy of accomplishment, and (2) because until malaria has been properly controlled liability to the occurrence of epidemic outbreak of the disease will continue.

455. In the body of the report minor measures of prevention, such as the use of mosquito nets, punkahs and fans are not discussed. They are largely personal matters which have little bearing upon the public prophylaxis of malaria.

456. Education also, although of great value, is not likely by itself to effect very much. Among the poor it is useless to talk of mosquito nets and ordinary measures of personal prevention, but they may be taught the value of quinine as a remedy for malaria and trained to make use of it for the relief of the disease. As a class the poor have little power to stop the spread of the malaria, because they cannot control the breeding places of dangerous *anopheles*, and it is therefore not of much use urging them to pour kerosine on water or to attempt similar measures; but among the educated and the wealthy, the property-owners and tax-payers, those who have a voice in the Municipal administration and who possess the power to eradicate malaria from the City, education regarding the prevention of malaria by public measures is needed, for the responsibility rests with them.

457. The use of quinine, though often of supreme importance where the mitigation of the disease is all that can be attempted, becomes of secondary importance in Bombay; and though the popularization of the remedy, its widespread distribution and the encouragement of its use in the treatment of existing infections are likely to be of great value, the taking of doses for the prevention of fever is seen at once to be a measure useful possibly for large employers of labour, among troops and prisoners and for private persons, but not adapted for large uncontrolled populations.

458. The conclusions that have been reached regarding the public measures of malaria prevention for Bombay are as follows:—

(1) The measures should be directed against mosquitoes, but the suppression or reduction of the species of anopheles that carry the disease must first be aimed at.

(2) The measures must be so contrived and directed as to bring about not merely a mitigation of the disease but the eradication of autochthonous malaria from the City.

(3) The more rapidly the measures are carried into effect the greater will be the certainty of their complete success.

459. Assuming that the Municipality decides to seriously attempt the eradication of malaria the following steps must be considered. It will be necessary to—

(1) decide whether the measures shall be taken against all mosquitoes or be directed specially against those responsible for malaria;

(2) vote sufficient money for the purpose;

(3) sanction the appointment of a Special Assistant to the Executive Health Officer, who can devote his whole time to the direction and supervision of the necessary measures;

(4) sanction an increase in the existing subordinate staff of the Health Department, so as to allow of the necessary numbers of Inspectors and labourers required for the work;

(5) obtain adequate legal powers for carrying out the necessary measures.

460. *The prevention of dangerous Anopheles or of all kinds of mosquitoes.*—In the *ad interim* report published in 1910 it was stated that the conclusion arrived at was that,

> "The prevention of dangerous *anopheles*, rather than the destruction "of all mosquitoes, must form the key-note of anti-mosquito sanitation "for Bombay."

In the present report the cost of an "all-mosquito-prevention scheme" and a "dangerous-anopheline-prevention scheme" have been compared.

461. There is much to be said in regard to the respective advantages of these two measures. It may be argued in support of "all-mosquito work" that, all mosquitoes are a nuisance, that certain species other than malaria-carrying *anopheles* carry disease, and that it is a good thing to attack them all. In particular it may be urged that *Culex fatigans* and *N. rossi* (possibly) convey *filariæ* (the cause of *elephantiasis*) to man; that dengue fever is supposed to be carried by culicine mosquitoes, that *Stegomyia calopus* (or *fasciata*) carries yellow fever and that Manson and others have already warned us that this disease may be introduced into Asia after the opening of the Panama Canal in 1915.

462. On the other hand it may be pointed out that, although an attack upon all kinds of mosquitoes may be an anti-malarial measure, unless it is carried out so carefully that the actual carriers of the disease are not passed over, it may easily degenerate, into the mere slaughter of the commonest species of *culex* and *anopheles* mosquitoes, and the disease-carriers really aimed at may almost entirely escape.

It may be pointed out also that, filarial infection is not common in Bombay and yellow fever does not exist there at present, moreover the breeding places infected with the carriers of malaria number only about 2,000, and many of them are of such a nature as easily to be neglected or passed over in a campaign directed against every kind of mosquito. The question of expenditure must be considered also, and it must be remembered that the cost of a strict anti-malaria campaign, directed mainly against the carriers of malaria, is likely to be very much less than a campaign against all mosquitoes, which to be successful against malaria must be absolutely thorough.

463. It appears probable that the wisest course to take in Bombay would be to commence with an attack directed specially against the malaria-carrier. Once the control of malaria has been achieved it will only be necessary to expand the organization to the required limit if the work is to be extended. As regards the danger from yellow fever, it may be pointed out that there is little question that an executive that can control malaria-carrying mosquitoes will find little difficulty in also controlling the yellow fever carrier *Stegomyia calopus* if it is found to be necessary.

464. *Expenditure.*—The question of expenditure must really decide the choice of complete or partial measures against mosquitoes. In the case of all-mosquito measures it will be necessary to allow for an expenditure of Rs. 2,00,000 to Rs. 5,00,000 per annum according to the area of work. But the cost of

measures against the malaria-carrier alone would not be very much more than Rs. 1,00,000 for the whole of A., B., C., D. and E. Wards, even were there no sanitary staff already employed there; and the area of more intense malaria (A., B. and C. Wards) if taken alone could probably be dealt with for a total expenditure of Rs. 50,000 per annum. The most dangerous permanent breeding places of the malaria-carrier—the house wells in the Fort and Dhobi Taláo—could probably all be protected by filling-in or providing proper covers for a capital expenditure of Rs. 50,000, and for another Rs. 50,000 one half of the remaining wells to the south of Grant Road could be effectively protected. Once this permanent work was carried through, current expenditure would be lessened.

465. *Special Officer.*—As regards the Special Assistant to the Health Officer, it may be pointed out that the appointment of such an officer is the most important part of the whole scheme. *It is absolutely essential that one responsible official shall be able to devote his whole time and attention to perfecting the details of the work and seeing that it is properly carried out.* He should be given as free hand as possible (subject to the control of the Executive Health Officer), both to initiate and superintend the work; *and he should be expected to furnish each year a report of the work done.* He would require a speedy conveyance to enable him to get about from place to place with as little loss of time as possible, and he would also need a small office and laboratory staff. It is probable that an officer from among the existing staff of the Health Department might be delegated for all-time work of this kind.

466. *Subordinate staff.*—As regards subordinate staff, the question is largely a matter of detail, for subsequent arrangement; but it may be pointed out that it will be necessary to allow for adequate inspection of any area in which work is undertaken, more or less on the lines laid down in the chapter in which the "Cost of Malaria Prevention" was discussed. As regards the well-cleaning gangs and fish-stocking gangs, the employment of which is an essential part of the scheme, the estimate given in the same chapter may be found to be either above or below the actual requirements. There should be no difficulty in obtaining a sufficient supply of suitable fish, either *Piku, Kazári* or cat-fish, from local sources.

467. *Legal Powers.*—The question of adequate legal powers is of great importance. Without them any scheme of work is bound to fail. In the chapter on "The Legal Aspect of Mosquito Prevention" the matter has been fully discussed, and it is only necessary to point out that "mosquito breeding" must be declared a statutory "nuisance" and power must be given to the Municipal Commissioner, not only to take the necessary action himself, but to delegate that power to the Executive Health Officer or a responsible assistant. The appointment of a responsible whole-time officer would in itself be a sufficient safeguard against oppression in carrying out the law, especially if power of appeal to the Municipal Commissioner were provided for.

468. In the *ad interim* report it was suggested that a scheme for registering and licensing collections of water, such as wells, etc., which form potential breeding places for the carriers of malaria, should form part of the anti-malaria campaign. This suggestion is likely to be of value especially in regard to wells. If on the one hand a special grant were made for filling in or permanently covering wells and on the other hand a license were required and small fee charged to those who wished to adopt a more uncertain method of protection (*i. e.*, well covers with a trap door, stocking with fish, or both) to cover the cost of periodical inspection, there would be a strong inducement to well-owners to choose the permanent method of protection. Further consideration does not suggest any great modification of the general preventive measures indicated in the *ad interim* report, and these suggestions should be taken as a guide.

469. In conclusion, it is only necessary to point out that, as the end to be achieved is the eradication of malaria from Bombay, permanent measures for the protection or abolition of breeding places of the malaria-carriers should have precedence over all others. But in places like the New Dock Works temporary

measures will be required for some time, and the Special Officer appointed should devote a large part of his time during the next two years to perfecting the measures of mosquito destruction now being carried out in that area.

470. As regards the use of quinine, it has already been pointed out that, it must take a subordinate place in Bombay. But it should not be entirely neglected on that account. The data obtained during the investigation shew, not only that quinine is readily welcomed by the people when supplied in a palatable form, but that many of them will gladly purchase sugar-coated tablets if they know where to obtain them in small quantities at a reasonable price; and shop-keepers and others readily become vendors of sugar-coated tablets if they are allowed a sufficient profit upon them.

471. The popularization of quinine is a matter that can best be furthered by the authorities, and the supply of suitable packets of the drug made up in a palatable form, such as that supplied by the Italian Government, would be a boon likely to be greatly appreciated. There is reason to suppose that the success of such a measure would largely depend upon the palatability of the preparation, and on this account sugar-coated tablets are to be greatly recommended.

472. As regards the gratuitous distribution of quinine, it may be pointed out that this is a measure eminently suited to philanthropic agencies. It may be suggested that the wealthier members among the different communities of Bombay should be asked to organize for the supply of gratuitous quinine treatment to the poorer people in the more malarious parts of the City. In this way sickness will be lessened and the larger work of malaria prevention be somewhat lightened.

473. Finally it may be urged that the measures that have been suggested should be given close consideration. It is often claimed that not only is Bombay the wealthiest City of India, but she is the largest as regards population and the most advanced as regards education and the general enlightment of her citizens. She possesses local self-government, and an up-to-date municipal administration, and her resources per head of the population are far larger than those of any other municipality in India The problem of malaria prevention in the City is far more easy, as far as natural difficulties are concerned, than that to be faced in many other places; not only can malaria be reduced, but it can be absolutely eradicated from the greater part of Bombay; and the expenditure required is not only well within the means of the City, but would amount to less than a tenth part of the loss occasioned each year by the disease.

APPENDIX I.

Note upon the non-malarial fevers of Bombay.

At one time it was customary to class almost all cases of febrile disease met with in India as malaria, either under the head of "Remittent Fever" or "Intermittent Fever" (Ague). No doubt many cases of non-malarial fever were thus included under the general heading of malaria; but now-a-days the tendency is to go to the other extreme and mild and evanescent fevers, many of which are undoubtedly due to malaria, are placed under another heading. By far the largest proportion of cases of fever met with in Bombay during the present investigation have been cases of malaria. These cases have been almost all of an intermittent type and very few cases of fever which would be generally called "Remittent" or "Continued", showed malarial parasites on examination of the blood. A few cases of Enteric Fever have been met with and a rather larger number of cases of the so-called "Bombay Fever", a continued fever lasting from 5 to 10 days. It has been remarked that this latter type of fever very frequently attacks people who have gone to reside in newly built houses.

In none of the 6,400 blood specimens examined during the investigation were the spirilla of Relapsing Fever seen. This is interesting in view of the fact that in 1907 and 1908 there was a small epidemic of relapsing fever in Bombay, the occurrence of which was recorded by Captain Mackie, I. M. S. A few cases of fever which had been reported as "Relapsing Fever" on clinical grounds, turned out to be malaria (malignant tertian) upon examination of the blood.

Powell in his paper upon "the Blood Examination of cases of Febrile Diseases in Bombay" (I. M. G. March 1904) records the following results in regard to 3,413 cases of "Fever":—

Diagnosed by the finding of parasites in the blood—

(1)	Malaria parasites present in	2,542
(2)	Spirilla of Relapsing Fever in	94
(3)	Plague Bacilli (out of 117 cases)	15
(4)	Filaria nocturna causing fever	1
		2,652

Cases in which blood examination was negative, subsequently diagnosed on other grounds—

(5)	Plague (except 15 mentioned above)	102
(6)	Pneumonia	92
(7)	Tuberculosis	94
(8)	Pleurisy, Influenza, Bronchitis	77
(9)	Enteric Fever	29
(10)	Gonorrhœa, Bubo and other form of sepsis ...	78
(11)	Syphilitic Fever	6
(12)	Lepra	4
(13)	Liver abscess	9
(14)	Small-pox, chicken-pox, measles, mumps, tonsillitis, etc.	60

Powell adds that "In 210 cases the diagnosis was reduced to unproved malaria (and undoubtedly the majority were such) febricula, or simple continued fever."

There are strong grounds for assuming that tuberculosis, plague, pneumonia and respiratory diseases are responsible for the largest number of so-called "Remittent Fevers" met with in Bombay. Tuberculosis is exceedingly common, many cases having been met with during the investigation. It is also exceedingly fatal, especially when it occurs among people of the poorer classes; and there are good reasons for believing that a very large proportion of the deaths recorded under the heading "Remittent fever" are due to this cause.

As regards the non-fatal short-term fevers prevalent in Bombay, it has already been pointed out that, the largest proportion show the presence of malarial parasites on blood examination; but it is probable that the existence of other specific fevers such as the recently discovered "Sand-fly Fever" may account for a proportion of the non-malarial fevers that are met with; and it is possible that fevers of this kind may be not uncommon in Mahim and other parts of the island, where malaria is prevalent to only a slight extent.

Kala-azar does not appear to occur in Bombay, and no case has been met with in a person belonging to the City; but a boy from Bengal suffering from Kala-azar was admitted to one of the hospitals in the City. The diagnosis was confirmed by the finding of Leishman-Donovan parasites after splenic puncture.

APPENDIX II.

Note upon Black-water Fever in Bombay.

Occasionally cases of Black-water fever are admitted to hospitals in Bombay; but in the majority of instances the patients do not appear to have belonged to the City. During the investigation however, two fatal cases of what appears to have been undoubted Black-water fever were reported. In neither case was the disease returned as Hæmoglobinuria. Unfortunately neither of the cases was seen, but a few particulars were obtained from the medical men who attended. One case occurred in the Frere Road and the other in the North Fort, both of which areas are intensely malarious. Both cases were children, one a Jewish boy aged 7 and the other a Parsi child. The Jewish boy had two attacks, a second one only a month after the 1st. He had suffered from fever and had a large spleen. During an attack of fever and after treatment with quinine he was suddenly attacked with persistent bilious vomiting, had a rigor and passed reddish-black urine. Next day he was seen to be intensely anaemic and jaundiced. He rallied rapidly but a month later fever again occurred and during treatment with quinine a sudden return of the former symptoms took place. This time he did not rally, but sank with symptoms of heart failure. In the other case there was a similar history, but the patient died of suppression of urine during the attack. In another fatal case of the disease which occurred in hospital in 1910, all that could be learned was the fact that the patient was a European, and had previously lived in Burma. No particulars could be obtained as to the length of his stay in Bombay or his place of residence, A definite history of Black-water fever was obtained from a European who lived at one time not far from Bombay in a small village reputed to be very malarious. These facts are recorded, as they have a definite bearing upon the relationship of Black-water fever to exposure to frequent infections by malaria.

APPENDIX III.

TABLE I.

CLIMATIC DATA FOR BOMBAY (COLABA).

Temperature (in degrees Fahrenheit).

	Means derived from 24 hourly observations 1847—1905.	Mean departure of the means.	Means for observation hours 1873—1905.			Diurnal range of temperature 1873—1905.		Mean monthly and annual extremes 1873—1905.		Mean monthly and annual range 1873—1905.	Absolute extremes (1847—1905).						Mean diurnal variabilit of temperature 1887—1896.
											Monthly means.		Daily means.		Individual hours.		
			6 A.M.	2 P.M.	10 P.M.	Periodic.	Non-periodic.	Maximum.	Minimum.		Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	
January ...	73·9	1·25	69·4	79·8	72·8	10·6	14·4	83·1	63·5	19·6	77·3	71·1	79·7	65 0	91·0	55·2	0·88
February ...	75·0	1·25	70·0	80·1	73·6	10·1	14·0	86·8	64·1	22·7	77·7	70 1	82·1	62·2	96·2	53·3	0·84
March ..	78·8	0·95	74·3	83·1	77·4	8·8	12·1	88·7	69·6	19·1	81·8	75·1	85·2	68·9	100·2	63·9	0·74
April ...	82·3	0·97	78·3	86·2	80·7	7·9	10·8	90·1	74·6	15·5	85·0	78·5	87·6	74·6	97·4	68·5	0·65
May ...	81·7	0·84	81·5	83·2	83·0	7 0	9·6	90 9	78·2	12·7	87·6	82·7	89·5	77·1	96·5	74·1	0·42
June ..	83·2	0·83	81·2	85·7	82·3	4·5	8·0	90·7	75·5	15·2	85 4	81·0	89·4	75·6	96·4	72·5	0·96
July ...	81·0	0·68	79·8	82·6	80·4	2·9	6·8	86·5	75·3	11·2	83·1	79·3	85·3	75·5	92·4	71·9	0·84
August ...	80·2	0·60	78·8	82·2	79·6	3·4	7·0	85·1	75·1	10·0	82·1	78·7	84·3	75·6	89·6	71·9	0·76
September ...	80·2	0·74	78·0	82·8	79·4	4·7	8·0	85·9	74·5	11·4	81·9	78·9	84·8	73·4	94·0	70 5	0·77
October ...	81·2	0·86	77·5	85·7	79·9	8·1	11·0	90·5	74·0	16·5	83·4	79 5	86·5	74·8	95·7	70·5	0·75
November ...	79·1	1·14	74·6	84·9	77·5	10·2	13·4	89·9	70·3	19·6	81·5	75·9	85·5	71·2	96·5	62·7	0·74
December ..	76·1	1·01	71·5	82·3	74·5	10·8	14·4	87·2	66 8	20·4	78·3	72·8	82·0	64·9	94·0	57·2	0·79
Year ...	79·6	0·54	76·2	83·6	78·4	7·4	10·8	92·4	62·3	30·1	87·6	70·1	89·5	62·2	100·2	53·3	0·76

APPENDIX III.

TABLE II.

CLIMATIC DATA FOR BOMBAY (COLABA).

Precipitation, Moisture, Wind.

	Rainfall, 1846-1905.				Cloudiness whole sky = 10 means derived from 5 typical observations during the day 1873-1905.	Moisture (1873—1896).							Wind (1873—1896).							
						Pressure of vapour.				Relative humidity of the air complete saturation—1·000.				Result and components (in miles per hour).							Mean velocity in miles per hour derived from 24 hourly observations.
	Average amount.	Greatest monthly and annual amount.	Greatest amount in one day.	Average number of rainy days.		6 A.M.	2 P.M.	10 P.M.	Means derived from 24 hourly observations.	6 A.M.	2 P.M.	10 P.M.	Means derived from 5 typical observations during the day.	7 to 8 A.M.		3 to 4 P.M.		10 to 11 P.M.		Means derived from 24 hourly observations.	
	In.	In.	In.	In.		In.	In.	In.	In.												
January ...	0·12	2·22	1·87	0·4	1·1	0·540	0·590	0·594	0·581	0·764	0·581	0·747	0·674	4·7 N.	6·0 E.	8·7 N.	9·6 W.	6·8 N.	0·8 W.	6·7 N.	0·7 W.	10·0
February ...	0·02	0·51	0·31	0·3	1·1	·559	·629	·611	·599	·769	·609	·746	·678	4·4 N.	4·2 E.	10·4 N.	11·2 W.	6·5 N.	1·3 W.	7·2 N.	2·8 W.	10·5
March ...	0·01	0·20	0·20	0·3	1·4	·692	·737	·723	·715	·827	·548	·782	·718	3·3 N.	2·6 E.	9·3 N.	13·5 W.	5·2 N.	4·1 W.	6·0 N.	5·2 W.	11·0
April ...	0·05	1·57	1·04	0·4	1·7	·796	·836	·825	·817	·841	·670	·806	·740	1·4 N.	0·7 E.	8·0 N.	14·7 W.	4·6 N.	5·7 W.	4·3 N.	6·5 W.	10·9
May ...	0·62	7·79	3·52	1·8	3·1	·856	·889	·880	·874	·821	·670	·800	·737	0·2 S.	2·5 W.	2·5 N.	13·9 W.	0·6 N.	6·7 W.	0·9 N.	7·6 W.	10·7
June ...	10·01	43·45	16·10	21·0	7·3	·895	·934	·910	·913	·869	·781	·851	·820	5·7 S.	5·8 W.	0·3 S.	12·2 W.	0·9 S.	7·3 W.	0·3 S.	8·4 W.	15·4
July ...	24·25	50·99	8·20	28·0	9·0	·876	·911	·886	·890	·895	·841	·885	·867	5·1 S.	16·0 W.	4·6 S.	17·6 W.	6·1 S.	15·8 W.	5·2 S.	16·5 W.	18·8
August ...	13·05	36·56	11·30	26·3	8·6	·846	·883	·853	·860	·825	·829	·878	·858	2·7 S.	12·8 W.	1·4 S.	15·4 W.	2·9 S.	12·9 W.	2·6 S.	13·8 W.	15·3
September ...	10·51	31·51	9·23	19·2	7·0	·838	·875	·845	·853	·795	·803	·873	·847	1·1 S.	5·3 W.	2·5 N.	11·9 W.	0·0	5·9 W.	0·3 N.	7·1 W.	19·9
October ...	2·02	10·40	4·27	4·7	3·4	·798	·850	·830	·829	·873	·706	·842	·783	1·5 S.	6·2 E.	5·5 N.	8·7 W.	2·7 N.	0·9 E.	2·9 N.	0·2 W.	9·3
November ...	0·43	5·33	2·48	1·2	1·7	·663	·693	·711	·698	·792	·587	·772	·692	3·9 N.	8·9 E.	7·0 N.	8·6 W.	5·2 N.	1·1 E.	5·3 N.	1·2 E.	9·7
December ...	0·06	1·14	0·96	0·3	1·8	·575	·607	·622	·614	·763	·554	·747	·668	4·7 N.	9·2 E.	7·3 N.	8·4 W.	6·1 N.	0·9 E.	6·1 N.	1·3 E.	9·8
Year ...	71·15	114·89	16·10	103·9	3·9	0·745	0·786	0·774	0·770	0·834	0·690	0·811	0·757	0·8 N.	0·2 W.	4·1 N.	12·1 W.	1·8 N.	4·8 W.	2·1 N.	5·5 W.	11·9

APPENDIX III.

TABLE III.

Table of Rainfall by Weeks from 1st of June.

	Weeks.	1906.	1907.	1908.	1909.	1910.
June	1	1·43	0·37	...	2·43	1·61
	2	4·44	1·32	1·64	3·88	1·22
	3	2·51	18·02	5·33	0·59	0 94
	4	5·32	2·73	3·83	7·45	18·67
July	5	1·33	14·23	12·93	4·20	2·80
	6	1·83	0·35	4·80	13·59	0·84
	7	5·26	14·18	3·00	7·24	0·06
	8	9·47	22·74	1·06	1·80	0·89
	9	0·79	8·10	4·25	7·40	5·37
August	10	1·37	12·8	2·94	1·09	8·32
	11	0·90	11·67	2·58	0·04	3·38
	12	5·22	1·47	2·89	1·10	2·04
	13	13·17	0·96	0·85	2·48	1·81
September ...	14	0·98	0·73	1·10	4·86	1·30
	15	1·22	1·23	0·42	3·80	0·11
	16	0·08	0·07	2·15	0·61	3·56
	17	1·71	0·05	3·13	7·70	2·36
October	18	0·12	0·92	...	0·28	11·98
	19	...	0·02	...	...	...
	20	...	...	0·01	...	...
	21	...	...	0·25	...	...
November ...	22	...	...	0 36	...	0·45
	23	...	...	...	...	0·03
	24	...	...	...	...	0 11

APPENDIX III.

TABLE IV.

Number of days in each week from 1st of June in which rainfall was ¼ inch or more.

	Weeks.	1906. Number of days with ¼ inch or more rainfall.	1907. Number of days with ¼ inch or more rainfall.	1908. Number of days with ¼ inch or more rainfall.	1909. Number of days with ¼ inch or more rainfall.	1910. Number of days with ¼ inch or more rainfall.
June	1	1	...	...	2	2
	2	3	1	2	3	1
	3	3	4	4	...	2
	4	4	3	2	3	5
July	5	3	2	6	4	5
	6	2	...	4	6	1
	7	6	3	4	4	...
	8	7	6	2	4	2
	9	1	4	6	7	3
August	10	3	1	6	1	6
	11	1	7	2	...	5
	12	3	3	4	2	1
	13	5	1	1	3	2
September	14	1	...	1	4	1
	15	2	2	...	3	...
	16	...	...	3	...	3
	17	1	...	3	6	2
October	18	...	1	...	...	3
	19	...	...	...	...	...
	20	...	...	...	...	...
	21	...	...	1	...	...
	22	...	...	1	...	1
November	23	...	...	...	...	...
	24	...	...	...	...	...

APPENDIX III.

TABLE V.

Maximum and Minimum Temperature in Bombay—Weekly Averages.

Weeks.	1906.		1907.		1908.		1909.		1910.	
	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.
1 ...	82·3	64·5	87·8	72·2	85·3	68·6	82·0	68·1	84·6	68·3
2 ...	80·6	64·4	84·0	70·0	80·3	67·2	79·8	65·9	82·5	68·4
3 ...	85·9	70·5	86·2	69·3	83·7	69·1	79·5	67·0	81·7	64·3
4 ...	80·1	66·1	83·9	68·4	83·7	68·5	80·7	65·5	84·2	65·8
5 ...	82·0	66·8	81·8	68·3	80·7	67·0	79·2	64·3	87·3	70·7
6 ...	80 7	65·6	82·7	69·6	84·8	66 7	81·8	66·7	87·7	70 3
7 ...	80·4	67·5	84·3	70·0	83 9	69·0	83·0	68·8	84·6	68·0
8 ...	81·8	67·6	83·5	68·9	84·9	68·9	83·5	69·6	85·9	68·1
9 ...	85·5	68·4	87·5	73·2	83·6	68·5	86·1	71·3	84·7	68·3
10 ...	83·9	71·4	85·6	73·0	84·3	69·9	85·7	71·5	85·0	69·6
11 ...	82·7	70·7	85·7	73·0	83·9	69·1	86·2	73·3	89·4	73·3
12 ...	83·6	71·3	86.6	74·3	84·7	72·6	86·8	73·6	88·7	74·9
13 ...	86·4	73 5	88·3	76·3	87·0	75·2	89·2	74·9	90·1	76·6
14 ...	87·0	74·2	90·9	77·7	88·7	76·4	88·0	75·1	89·3	77·0
15 ...	87·0	74·8	89·9	78 3	88·5	76·5	88·2	75·8	90 7	76·8
16 ...	87·2	76·0	87·3	79·5	91·4	78·6	88·6	75·1	89·7	76·7
17 ...	89·3	77·2	89·4	78·8	87·0	77·5	89·9	78·3	91·1	78·0
18 ...	90·2	78·4	90·2	78·8	89·9	78·9	91·7	80·2	89·8	78·1
19 ...	90·9	80·6	90·3	78·2	89·9	80·1	90·8	81·5	90·5	79·1
20	91·6	81·1	91·3	80·5	91·1	80·1	92·0	81·7	91·0	80·9
21 ...	92·3	81·8	91·8	81·1	90·1	80·1	92·9	82·3	92·2	81 5
22 ...	92·5	82·9	92·5	81·5	92·2	83·0	94·1	83·2	92·6	81·4
23 ...	91·9	80·4	91·6	81·4	92·2	82·7	90·2	79·4	86·7	79·3
24 ...	87·2	77·6	89·7	78·6	90·0	80·4	87·7	81·1	87·7	80·0
25 ...	80·3	77·2	85·6	78·7	87·0	79·6	87·1	79·9	86·9	78·9
26 ...	86·9	79·8	86·5	80·0	87·7	80·0	85·2	77·4	84·7	78·4
27 ...	86·2	78·8	85·9	78·0	82·5	77·3	84·8	77·5	84·0	78·7
28 ...	85·0	78·5	88·4	80·5	83·5	77·6	81·5	76·3	86·3	79·3
29 ...	82·6	76·5	84·0	76·8	84·8	78·5	83·9	77·2	87·5	79·6
30 ...	82·9	77·5	82·0	76·0	84·3	78·1	84 6	64·7	85·4	78·0
31 ...	85·5	78·8	83 8	76·0	82·1	76·6	81·0	75·7	83·1	77·0
32 ...	85·3	78·1	82·4	76·6	83·7	76·9	85·9	77·7	82·4	76·2
33 ...	86·4	78 6	81·6	86·3	83·6	76·6	86·7	77·9	83·8	77·7
34 ...	83·7	76·6	83·2	77·2	83·2	76·6	84·2	76·5	84·9	77·7
35 ...	82·8	77·2	84·1	76·4	83·0	77·0	85·6	77·3	84·5	77·2
36 ...	84·8	77·4	85·2	76·2	83·7	76·8	83·9	76·8	85·7	77·7
37 ...	85·0	77·0	85·0	77·0	84·8	76·3	85·7	76·3	84·2	77·0
38 ...	85·1	77·1	87·5	76·2	86·3	77·6	83·7	75·5	81·2	74·6
39 ...	85·5	77·2	87·0	77·8	87·9	78·5	81·5	75·2	85·1	76·8
40 ...	86·8	76·9	88·1	78·9	88·1	77·6	86·3	77·1	84·3	77·7
41 ..	89·2	77·5	88·7	77·5	87 5	76·5	88·2	76·9	86·8	76·5
42 ...	89·5	76·5	88·4	77·1	88·8	76·6	90·1	75·5	87·3	74·3
43 ...	90·8	75·6	87·8	76·8	89·0	78·4	87·6	73·2	88·3	74·3
44 ...	88·0	76·1	90·9	75 7	87·4	73·3	87·5	75·7	88·6	75·3
45 ...	88·8	75·4	90·5	76·1	87·0	74·4	89·2	73·9	85·9	74·2
46 ..	89·9	75·1	88·6	73·7	85·4	72·2	87·8	71·8	85·3	71·1
47 ...	90·4	76·3	88 7	75·4	85·1	69·5	86·5	71·2	85·2	70·1
48 ..	88·7	72·6	88·2	74·4	85·8	69·2	86·6	71·5	85·7	68·3
49 ...	88·2	71·8	85·0	68·9	84·8	68·3	83·9	69·7	86·0	69·9
50 ...	87·5	71·1	86·8	69·8	84·3	68·7	82·5	69·8	85·1	69·3
51 ...	83·9	70·6	85·7	69·7	83·8	67·4	83·3	69·9	82·6	67·7
52 ...	86·3	71·3	89·1	69·2	82·6	67·7	84·2	70·0	83·0	68·8

APPENDIX III.

TABLE VI.

Relative Humidity in Bombay—Weekly Averages.

Weeks.	1906.	1907.	1908.	1909.	1910.
1	73	75	70	66	69
2	67	74	71	79	83
3	69	71	74	81	72
4	76	78	74	74	69
5	72	78	74	71	64
6	75	79	62	78	67
7	79	76	78	86	69
8	72	69	58	80	67
9	59	61	71	62	68
10	74	78	57	65	68
11	81	77	68	77	65
12	81	73	81	76	70
13	77	71	80	75	79
14	75	75	75	81	77
15	76	74	62	75	68
16	81	73	78	72	74
17	73	69	78	76	75
18	80	70	76	78	74
19	78	73	73	72	78
20	71	74	72	74	80
21	72	71	73	75	73
22	71	73	71	74	75
23	78	73	72	83	86
24	86	82	84	82	82
25	90	85	84	83	53
26	83	86	83	88	88
27	87	85	87	88	83
28	87	84	88	90	80
29	93	92	85	88	79
30	88	89	86	87	89
31	85	86	88	90	90
32	85	88	88	84	88
33	85	74	87	84	87
34	93	87	87	91	88
35	86	83	87	90	91
36	84	83	89	92	82
37	84	84	89	85	89
38	89	83	92	92	92
39	85	89	89	92	93
40	84	89	86	84	88
41	81	82	87	86	86
42	80	83	82	80	84
43	66	83	79	82	73
44	79	74	90	86	78
45	77	72	79	75	75
46	74	69	72	76	74
47	68	73	70	75	58
48	66	65	68	65	71
49	66	70	67	74	76
50	71	58	70	81	76
51	75	62	74	88	78
52	68	70	64	82	80

APPENDIX IV.

TABLE 1.

Area, Houses and Population (1906 Census).

Section.		Area in acres.	Houses.		Total Population.	Density per acre.	Number of occupied houses in 100 acres.
			Occupied.	Unoccupied.			
A. Ward ...	Upper Colaba ...	144·19	38	6	3,775	26	26
	Lower Colaba ...	283·92	450	220	15,310	54	151
	Fort, South ..	131·70	233	106	3,994	30	176
	Fort, North ..	134·30	1,020	210	28,778	214	759
	Esplanade ...	663·77	598	135	11,015	16	90
B. Ward ...	Chakla ...	51·58	812	165	29,362	569	1,574
	Mandvi ..	164·66	915	342	38,158	232	555
	Umarkhadi ...	105·33	1,041	162	53,610	509	988
	Dongri ..	285·47	535	279	32,663	114	187
C. Ward ...	Market ...	89·11	902	191	35,305	396	1,012
	Dhobi Talao ..	99·69	1,126	193	36,594	367	1,129
	Phanaswadi ..	125·23	802	135	29,240	233	640
	Bhuleshwar ...	75·79	1,123	206	38,129	503	1,481
	Kumbharwada ...	46·06	642	96	32,784	712	1,393
	Khara Talao ...	41·64	575	105	26,935	647	1,380
D. Ward ...	Khetwadi ...	170·30	1,255	321	33,579	197	736
	Girgaum ...	124·60	1,027	206	28,449	228	824
	Chaupati	111·77	775	306	13,033	117	693
	Walkeshwar ...	545·43	1,354	495	12,685	23	248
	Mahalakshmi ...	642·01	1,684	618	24,650	38	262
E. Ward ...	Tardeo ...	228·68	593	275	28,193	123	259
	Kamatipura ...	66·14	1,030	238	36,484	552	1,557
	1st Nagpada ...	29·60	67	39	3,335	113	226
	2nd Nagpada ...	34·00	486	58	22,016	647	1,429
	Byculla ...	511·52	1,621	501	76,280	149	316
	Tarwadi ...	479·68	1,057	565	26,278	55	220
	Mazagaon ...	638·59	1,216	435	30,872	48	190
F. Ward ...	Parel ...	552·45	1,182	552	46,960	85	213
	Sewri ...	445·72	176	261	15,985	36	218
	Sion ...	4,261·08	2,400	969	30,515	7	56
G. Ward...	Mahim ...	1,286·23	2,677	849	31,178	24	208
	Worlee ...	1,815·64	3,057	1,294	69,488	38	169
Harbour and Docks, Railways and Homeless.		.....	...	...	82,440	...	...
	Total ..	14,385·591	33,267	10,533	977,822	68	231

APPENDIX V.

TABLE I.

Statement showing the number of deaths from various causes between 1848 and 1909.

Year.	Population.	Deaths from Cholera.	Other bowel complaints.	Deaths from Fever.	Small-pox.	Other diseases.	Total number of deaths.	Ratio per 1000.
1848		69	1,090	4,859	839	3,194	10,051	17·75
1849		2,128	1,356	5,566	343	3,435	12,828	22·65
1850		2.997	1,245	5,555	1,308*	4,032	15,137	26·73
1851		5,485	1,321	4,808	510	3,826	15,950	28·17
1852	566,119	1,520	1,425	5,913	1,003*	4,161	14,022	24·76
1853		1,148	1,471	6,219	677	4,132	13,647	24·10
1854		3,507	1,763	8,219	232	3,820	17,541	30·98
1855		1,645	1,567	6,922	1,088*	3,640	14,826	26·25
1856		1,816	1,621	7,281	179	3,834	14,761	26·07
1857		2,181	1,735	7,857	346	5,707	17,826	31·48
1858		115	1,259	7,508	1,714*	3,745	14,342	25·33
1859		1,985	1,170	7,016	374	3,704	14,249	25·16
1860		1,961	1,179	6,226	166	4,877	14,409	25·45
1861		641	1,589	6,847	1,627*	4,310	15,014	26·52
1862		3,170	1,467	6,979	163	4,030	15,809	27·92
1863		2,209	1,643	9,078	1,059*	4,707	18,696	33·02
1864	783,980	4,847	1,503	12,593	1,707*	4,365	25,015	31·90
1865		2,887	1,581	18,767	567	4,729	28,531	36·39
1866		332	1,184	9.870	1,079*	4,400	16,865	21·51
1867		111	1,631	5,674	1,055*	7,029	15,500	19·77
1868		227	1,645	5,481	1,123*	7,226	15,702	20·02
1869		754	1,697	5,108	1,725*	8,429	17,713	22·59
1870		386	1,285	4,745	556	7,914	14,888	18·99
1871		263	1,346	6,341	919	7,195	16,064	20·49
1872		190	1,670	7,512	1,854*	7,464	18,990	29·46
1873		95	1,611	6,156	714	7,089	15,665	24·30
1874		20	1,648	5,403	261	8,164	15,496	24·04
1875		847	2,265	5,244	248	10,130	18,734	29·71
1876	644,405	378	1,979	5,867	3,174*	9,385	20,873	32·25
1877		2,550	3,847	12,832	958*	13,324	33,511	52·00
1878		1,183	3,078	9,944	357	12,437	26,999	41·89
1879		324	2,494	8,445	479	10,785	22,527	34·95
1880		30	1,728	7,513	207	11,668	21,146	32·81
1881		546	2,062	6,437	35	12,776	21,856	28·26
1882		192	1,618	5,453	92	13,113	20,468	26·47
1883		1,027	1,806	5,903	1,461*	13,333	23,530	30·43
1884		576	1,716	6,530	112	13,608	22,542	29·15
1885	773,196	598	1,545	6,648	55	13,004	21 850	28·25
1886		16	1,516	5,820	19	12,703	20,074	25·96
1887		269	1,640	5,612	108	12,884	20,513	26·53
1888		379	1,716	6,642	482	13,202	22,421	28·99
1889		462	1,724	7,266	304	13,622	23,378	30·23
1890		102	1,412	6,489	150	12,381	20,534	26·55
1891		164	1,501	6,837	108	15,237	23,847	29·01
1892		169	1,823	7,751	541	16,234	26,518	32·26
1893		147	1,698	5,844	201	15,252	23,142	28·16
1894		426	2,344	6,458	531	16,571	27,330	33·25
1895		90	1,813	6,404	270	16,504	25,081	30·52
1896	821,764	490	2,350	8,776	701	21,134	33,451	40·71
1897		1,265	3,551	6,951	57	36,072	47,896	58·28
1898		104	3,385	4,114	55	44,303	51,961	63 23
1899		111	4,286	5,063	440	46,534	56,434	68·07
1900		4,273	8,676	7,928	3,018*	55,455	79,350	96·35
1901		198	3,716	7,921	159	47,501	59,495	76·66
1902		75	3,269	4,518	288	40,264	48,414	62·38
1903	776,006	17	3,134	2,333	1,477*	43,552	50,513	65·09
1904		219	2,784	2,416	568	36,689	42,676	54·99
1905		26	3,391	2,878	2,161*	39,306	47,762	61·54
1906		1,241	4,778	4,882	276	41,697	52,874	53·97
1907	977,822	439	3,489	3,633	86	31,040	38,687	39·56
1908		95	3,184	3,403	1,026*	30,563	38,271	39·13
1909		727	2,585	2,800	473	28,293	34,878	35·66

* These were epidemic years.

APPENDIX VI.

TABLE I.

Municipal Dispensaries at Colaba, Upper and Middle, Colaba Section, A. Ward.

Monthly admissions.		1903.	1904.	1905.	1906.	1907.	1908.	1909.	1910.
January	Total	612	573	607	722	580	629	421	445
	Fever	166	225	187	204	203	218	142	137
February	Total	504	473	476	575	466	481	391	436
	Fever	115	202	134	188	261	157	112	119
March	Total	591	501	501	785	527	472	532	342
	Fever	139	213	125	230	167	153	185	141
April	Total	543	726	558	842	627	578	603	584
	Fever	137	271	206	288	224	175	223	181
May	Total	596	757	582	801	615	524	574	499
	Fever	124	323	217	277	245	169	277	158
June	Total	598	568	495	693	617	560	452	419
	Fever	125	219	157	272	220	209	172	148
July	Total	718	648	488	1,081	761	570	745	651
	Fever	244	266	143	654	350	233	307	188
August	Total	1,023	663	693	1,226	811	680	877	626
	Fever	386	318	227	664	352	283	449	253
September	Total	854	612	716	974	881	805	756	548
	Fever	400	300	319	464	419	364	427	167
October	Total	699	569	748	899	915	888	766	660
	Fever	306	242	359	471	430	557	375	256
November	Total	692	563	642	848	712	609	641	577
	Fever	297	230	265	390	290	354	281	191
December	Total	563	476	738	697	676	533	576	548
	Fever	227	149	270	255	258	257	206	116

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TABLE II.

Municipal Dispensary at Frere Road, Fort Section, A. Ward.

Monthly admissions.		1903.	1904.	1905.	1906.	1907.	1908.	1909.	1910.
January	Total	308	452	454	764	772	709	551	543
	Fever	128	212	206	350	379	360	254	212
February	Total	269	429	407	776	638	588	503	483
	Fever	101	205	150	339	268	249	232	215
March	Total	303	467	480	862	712	729	600	529
	Fever	108	210	191	402	356	375	267	205
April	Total	319	465	493	759	688	848	534	507
	Fever	98	197	171	306	329	466	249	238
May	Total	339	473	604	680	808	1,100	609	590
	Fever	108	202	237	259	457	769	321	288
June	Total	365	491	556	700	868	926	710	611
	Fever	125	218	205	277	531	618	418	322
July	Total	444	688	661	900	979	941	771	866
	Fever	167	289	282	397	606	569	408	457
August	Total	524	712	873	1,102	1,255	1,143	902	806
	Fever	249	319	416	555	806	718	479	465
September	Total	488	586	856	899	1,211	1,335	912	771
	Fever	213	236	477	480	759	851	567	373
October	Total	556	664	1,009	958	1,504	1,489	775	875
	Fever	257	364	569	512	992	1,088	420	510
November	Total	558	631	1,011	982	1,074	1,119	666	696
	Fever	268	299	662	571	578	719	355	387
December	Total	420	497	916	777	911	739	625	674
	Fever	258	233	520	404	523	391	271	342

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TABLE III.

Municipal Dispensary No. 2 at Kolsa Mohla, Chakla Section, B. Ward.

Monthly admissions.		1903.	1904.	1905.	1906.	1907.	1908.	1909.	1910.
January	Total	175	443	403	280	270	278	263	362
	Fever	10	11	14	10	12	24	21	60
February	Total	140	369	308	314	246	284	254	300
	Fever	12	10	14	11	10	13	12	38
March	Total	193	380	304	336	276	354	291	326
	Fever	9	12	10	12	11	8	14	24
April	Total	229	366	414	299	243	220	247	302
	Fever	7	9	8	6	10	15	15	24
May	Total	235	453	356	316	336	262	295	309
	Fever	11	8	7	6	7	5	27	16
June	Total	355	375	315	227	294	283	256	295
	Fever	10	6	7	4	5	11	31	30
July	Total	480	587	309	300	338	266	357	450
	Fever	8	4	5	7	8	19	29	72
August	Total	599	582	392	404	392	338	459	408
	Fever	12	10	6	5	9	51	64	67
September	Total	467	509	384	345	372	418	477	454
	Fever	14	11	10	17	19	60	127	64
October	Total	463	535	380	482	378	475	519	357
	Fever	12	11	9	4	6	59	182	72
November	Total	480	461	346	367	370	406	430	365
	Fever	10	13	8	10	10	78	126	43
December	Total	450	435	309	332	361	296	358	287
	Fever	14	9	7	11	2	84	61	28

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TABLE IV.

Municipal Dispensary No. 3 at Mázagaon Bridge, Umarkhádi Section, B. Ward.

Monthly admissions.		1903.	1904.	1905.	1906.	1907.	1908.	1909.	1910.
January	Total	308	292	1,062	1,036	925	853	705	519
	Fever	.....	.....	318	396	310	286	41	55
February	Total	305	281	910	1,111	802	829	710	540
	Fever	.....	.....	305	381	298	278	49	47
March	Total	306	276	1,054	1,006	910	849	821	684
	Fever	.....	.....	290	371	291	260	74	41
April	Total	262	250	1,072	1,009	919	850	816	772
	Fever	.....	.....	271	346	286	243	18	45
May	Total	260	218	1,114	1,008	1,009	765	736	761
	Fever	.....	.....	261	311	262	231	28	41
June	Total	242	210	1,003	1,015	887	818	757	667
	Fever	.....	.....	259	313	240	224	35	45
July	Total	235	205	976	1,131	852	872	827	1,030
	Fever	.....	.....	248	314	241	220	51	63
August	Total	230	201	1,054	1,096	932	836	745	939
	Fever	.....	.....	240	310	263	224	92	85
September	Total	263	221	1,130	1,091	1,058	844	923	919
	Fever	.....	.....	301	321	274	230	139	56
October	Total	301	231	1,355	1,209	1,100	865	904	1,064
	Fever	.....	.....	308	330	301	254	186	135
November	Total	303	253	1,225	1,233	1,068	958	947	1,023
	Fever	.....	.....	311	358	303	271	176	102
December	Total	307	271	1,120	995	863	909	887	714
	Fever	.....	.....	314	372	313	295	72	70

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TABLE V.

Municipal Dispensary No. 4 at Cathedral Street, Bhuleshwar Section, C. Ward.

Monthly admissions.		1903.	1904.	1905.	1906.	1907.	1908.	1909.	1910.
January	Total	34	224	201	188	267	248	258	502
	Fever	.....	60	66	60	64	11	64	113
February	Total	35	188	194	218	221	262	307	430
	Fever	.....	41	33	45	43	15	100	98
March	Total	41	234	221	243	293	212	323	415
	Fever	.....	76	59	54	74	9	83	97
April	Total	32	250	256	265	255	234	287	363
	Fever	.....	44	51	44	48	12	54	75
May	Total	20	263	213	235	255	342	269	354
	Fever	.....	71	38	28	70	13	66	66
June	Total	31	232	256	262	272	306	279	415
	Fever	.....	25	45	42	24	24	57	60
July	Total	23	229	238	260	216	292	347	452
	Fever	.....	29	49	48	25	17	87	79
August	Total	36	221	255	295	256	392	210	418
	Fever	.....	46	54	59	41	37	55	71
September	Total	24	260	285	267	267	285	284	411
	Fever	.....	38	63	66	34	39	70	71
October	Total	28	281	279	239	306	348	335	441
	Fever	.....	50	53	54	50	60	101	95
November	Total	35	238	246	289	235	378	399	427
	Fever	.....	18	70	65	14	41	123	77
December	Total	57	202	260	295	219	345	506	366
	Fever	.....	11	79	70	8	11	151	58

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TABLE VI.

Municipal Dispensary No. 5 at Grant Road, Kumbhárwáda Section, C. Ward.

Monthly admissions.		1903.	1904.	1905.	1906.	1907.	1908.	1909.	1910.
January	Total	84	787	746	755	568	669	707	3,331
	Fever	.....	94	76	144	111	89	46	84
February	Total	72	612	729	605	507	578	516	3,416
	Fever	.....	88	86	126	84	76	30	71
March	Total	120	569	773	799	575	693	730	3,655
	Fever	.....	110	70	143	95	105	57	59
April	Total	101	774	696	736	565	708	798	949
	Fever	.....	105	53	131	98	83	65	50
May	Total	93	774	793	698	578	659	745	948
	Fever	.....	85	66	100	105	96	41	34
June	Total	70	618	703	632	690	623	646	1,026
	Fever	.....	65	86	98	118	124	66	71
July	Total	120	831	840	597	735	568	791	1,370
	Fever	.....	112	103	92	129	137	55	119
August	Total	134	1,009	1,031	809	961	652	1,035	1,231
	Fever	.....	124	137	99	165	141	67	118
September	Total	140	896	1,077	850	909	721	994	1,166
	Fever	.....	135	163	109	180	198	51	126
October	Total	215	932	1,023	782	505	730	1,305	1,252
	Fever	.....	195	169	118	130	116	95	156
November	Total	124	763	897	758	825	682	987	1,103
	Fever	.....	109	131	147	149	135	88	145
December	Total	73	807	831	724	937	753	853	944
	Fever	.....	83	151	156	130	147	79	55

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TABLE VII.

Municipal Dispensary No. 6 at Kándewádi, Girgaum Section, D. Ward.

Monthly admissions.		1903.	1904.	1905.	1906.	1907.	1908.	1909.	1910.
January	Total	281	345	364	299	323	441	390	315
	Fever	84	91	62	89	81	80	121	60
February	Total	181	248	226	235	250	294	315	296
	Fever	66	83	64	84	82	75	109	86
March	Total	167	267	190	273	276	300	295	264
	Fever	58	82	56	93	81	97	98	77
April	Total	193	278	232	197	270	299	267	240
	Fever	68	74	51	81	98	89	91	66
May	Total	251	353	292	299	342	298	383	201
	Fever	66	110	64	77	97	81	119	55
June	Total	294	304	295	311	353	350	362	310
	Fever	85	81	72	103	143	126	123	61
July	Total	358	398	381	398	455	408	418	425
	Fever	105	111	94	138	154	124	172	89
August	Total	443	412	407	449	478	434	410	352
	Fever	148	160	95	147	176	131	138	79
September	Total	445	400	451	446	521	481	376	311
	Fever	161	132	105	179	181	149	119	32
October	Total	420	408	423	420	502	432	450	396
	Fever	133	120	110	181	182	174	77	62
November	Total	374	371	355	425	461	424	364	343
	Fever	130	143	102	193	188	153	104	62
December	Total	361	351	332	290	413	372	330	310
	Fever	138	103	101	161	138	122	94	63

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TABLE VIII.

Municipal Dispensary No. 7 at Belasis Road, Byculla Section, E. Ward.

Monthly admissions.		1903.	1904.	1905.	1906.	1907.	1908.	1909.	1910.
January	Total	135	1,627	1,727	1,195	1,002	798	810	788
	Fever	...	227	138	116	43	30	64	39
February	Total	100	1,597	1,358	1,200	934	601	868	812
	Fever	...	206	88	67	50	38	22	22
March	Total	220	1,485	1,503	1,320	1,007	698	931	873
	Fever	...	248	87	130	67	45	33	10
April	Total	269	1,430	1,339	1,291	912	655	835	801
	Fever	...	254	91	125	73	40	15	1
May	Total	190	1,478	1,430	1,347	938	634	864	901
	Fever	...	189	60	117	90	45	32	10
June	Total	180	1,523	1,291	1,303	922	620	727	752
	Fever	...	97	97	54	83	42	12	9
July	Total	224	1,491	1,222	1,288	1,003	604	903	1,058
	Fever	...	136	118	59	85	50	46	15
August	Total	310	1,298	1,372	1,446	1,247	899	1,142	923
	Fever	...	165	111	46	82	62	54	23
September	Total	263	1,366	1,144	1,445	1,085	1,031	947	878
	Fever	...	119	130	57	93	83	41	11
October	Total	285	1,487	1,295	1,520	1,351	959	1,087	998
	Fever	...	160	242	84	105	75	51	17
November	Total	330	1,508	1,099	1,303	996	1,027	956	914
	Fever	...	173	139	86	90	70	91	6
December	Total	248	1,536	1,145	1,240	921	788	910	672
	Fever	...	185	171	73	69	45	40	9

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TABLE IX.

Municipal Dispensary No. 8 at Foras Road, Tardeo Section, E. Ward.

Monthly admissions.		1903.	1904.	1905.	1906.	1907.	1908.	1909.	1910.
January	Total	867	760	978	827	738	803	681	561
	Fever	105	69	147	150	150	124	115	54
February	Total	662	659	899	764	625	764	679	513
	Fever	107	32	142	146	110	103	108	36
March	Total	712	701	967	1,089	755	795	791	551
	Fever	85	48	158	266	132	66	128	61
April	Total	820	627	1,059	966	748	764	675	543
	Fever	73	42	159	239	160	85	135	65
May	Total	802	682	1,050	898	736	690	687	459
	Fever	69	37	150	181	113	113	110	34
June	Total	845	673	785	770	631	743	696	589
	Fever	101	41	159	158	121	140	111	27
July	Total	948	971	909	825	717	809	787	882
	Fever	93	82	183	138	144	136	139	108
August	Total	1,116	1,092	1,018	1,140	798	826	859	696
	Fever	109	87	201	220	172	144	131	86
September	Total	1,179	1,024	981	971	898	992	726	662
	Fever	123	95	214	191	193	176	129	61
October	Total	1,140	1,052	1,097	933	966	990	821	698
	Fever	159	108	233	205	205	222	179	53
November	Total	1,034	960	868	898	862	896	786	637
	Fever	135	40	195	264	195	168	176	91
December	Total	881	843	890	713	929	838	687	581
	Fever	119	41	197	143	198	129	99	91

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TABLE X.

Municipal Dispensary No. 9 at Elphinstone Road, Parel Section, F. Ward.

Monthly admissions.		1903.	1904.	1905.	1906.	1907.	1908.	1909.	1910.
January	Total	440	342	438	462	334	374	286	570
	Fever	33	68	51	29	36	64	33	39
February	Total	270	308	345	443	317	290	282	518
	Fever	17	20	30	18	18	30	20	55
March	Total	313	357	348	510	360	392	367	574
	Fever	26	10	9	9	19	37	26	48
April	Total	322	373	369	448	375	340	394	579
	Fever	25	22	13	13	9	44	38	31
May	Total	270	320	400	385	405	407	369	565
	Fever	22	21	13	19	19	50	32	46
June	Total	309	329	386	419	340	411	449	578
	Fever	28	19	11	8	15	51	28	31
July	Total	592	582	430	521	423	257	613	919
	Fever	45	32	17	12	22	29	54	94
August	Total	668	673	605	616	499	336	649	860
	Fever	58	32	28	25	22	36	55	73
September	Total	508	511	607	520	511	403	654	804
	Fever	47	24	18	20	28	51	67	88
October	Total	519	439	511	418	484	415	868	938
	Fever	77	50	20	37	68	102	59	90
November	Total	520	376	460	502	490	448	687	827
	Fever	35	16	39	38	66	100	84	102
December	Total	447	389	481	420	391	336	621	702
	Fever	84	29	40	33	71	76	55	80

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TABLE XI.

Municipal Dispensary No. 10 at DeLisle Road, Worlee Section, G. Ward.

Monthly admissions.		1903.	1904.	1905.	1906.	1907.	1908.	1909.	1910.
January	Total	1,589	1,105	1,019	1,204	923	1,192	730	1,092
	Fever	109	107	137	141	139	129	54	35
February	Total	1,085	1,127	983	1,060	664	973	786	909
	Fever	116	114	117	134	117	110	100	46
March	Total	1,139	1,198	1,065	1,123	860	1,008	883	932
	Fever	169	171	179	167	187	169	81	44
April	Total	1,227	976	988	1,128	813	908	896	814
	Fever	187	189	193	189	179	191	73	42
May	Total	1,322	668	1,041	1,148	892	861	907	856
	Fever	199	178	201	199	189	163	47	53
June	Total	1,422	1,175	1,099	1,141	828	839	925	977
	Fever	206	194	196	203	187	196	34	42
July	Total	1,512	1,463	1,336	1,186	797	994	908	723
	Fever	101	115	113	99	97	85	45	47
August	Total	1,502	1,475	1,691	1,370	820	1,401	1,238	933
	Fever	123	119	143	107	111	93	50	50
September	Total	1,472	1,449	1,765	1,224	1,013	1,070	1,079	998
	Fever	111	109	117	136	121	119	62	56
October	Total	1,465	1,653	1,623	1,163	1,042	953	1,037	1,046
	Fever	139	117	113	131	107	99	97	75
November	Total	1,266	1,435	1,336	961	1,198	868	750	903
	Fever	129	99	96	119	139	91	47	68
December	Total	1,285	1,289	1,154	917	1,146	571	756	778
	Fever	111	127	109	136	107	89	35	42

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TABLE XII.

Northcote Police Hospital.

Monthly admissions.		1901.	1902.	1903.	1904.	1905.	1906.	1907.	1908.	1909.	1910.
January	Total	161	144	168	140	131	153	110	163	154	144
	Fever	88	67	76	60	59	74	41	89	98	43
February	Total	160	134	102	103	132	118	99	125	124	134
	Fever	85	56	42	47	43	58	21	58	70	42
March	Total	95	137	138	109	93	124	108	128	133	123
	Fever	38	59	39	36	21	44	30	48	62	47
April	Total	143	160	103	112	107	152	125	112	157	125
	Fever	69	79	56	37	42	67	36	62	81	66
May	Total	142	155	101	142	114	148	144	184	177	109
	Fever	74	61	42	49	36	79	43	100	92	52
June	Total	113	152	103	133	125	133	125	175	231	140
	Fever	51	59	45	64	45	63	37	118	132	64
July	Total	164	171	157	177	147	189	168	214	255	247
	Fever	101	78	86	82	76	85	72	119	144	134
August	Total	191	156	146	177	186	186	211	241	223	231
	Fever	128	79	73	81	110	110	80	164	137	103
September	Total	189	141	142	215	231	175	186	307	328	250
	Fever	114	73	72	141	154	78	132	230	241	160
October	Total	190	202	147	182	275	192	237	372	302	293
	Fever	122	125	70	111	200	98	164	323	211	291
November	Total	207	174	204	160	207	202	215	273	218	233
	Fever	149	116	126	107	134	86	143	119	117	145
December	Total	130	160	159	153	190	129	191	208	186	175
	Fever	76	101	88	82	114	48	114	99	70	80

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TABLE XIII.

Jaffer Suleman Dispensary.

Monthly admissions.		1905.	1906.	1907.	1908.	1909.	1910.
January ...	Total ...	603	659	556	572	618	713
	Fever ...	37	41	36	46	103	94
February ...	Total ...	559	468	396	475	603	685
	Fever ...	32	40	25	38	60	63
March ...	Total ...	611	667	487	571	851	611
	Fever ...	30	38	19	28	93	83
April ...	Total ...	727	608	527	650	694	778
	Fever ...	36	38	22	30	60	120
May ...	Total ...	843	741	624	650	851	696
	Fever ...	52	58	25	67	38	107
June ...	Total ...	679	656	577	692	767	642
	Fever ...	44	25	37	155	66	121
July ...	Total ...	756	665	655	714	843	875
	Fever ...	42	44	41	98	219	21
August ...	Total ...	816	704	671	806	865	779
	Fever ...	50	34	45	68	181	45
September ...	Total ...	797	655	710	700	695	741
	Fever ...	48	49	48	100	193	31
October ...	Total ...	628	700	799	813	848	763
	Fever ...	16	44	43	157	261	43
November ...	Total ...	584	704	662	871	841	764
	Fever ...	32	42	32	231	244	70
December ...	Total ...	653	516	563	659	721	620
	Fever ...	29	38	35	64	133	55

TABLE XIV.

Port Trust Dispensary.

Monthly admissions.		1906.	1907.	1908.	1909.	1910.
January	Total ...	329	302	308	352	406
	Fever ...	83	78	94	131	122
February	Total ...	336	255	262	349	372
	Fever ...	86	56	72	133	115
March	Total ...	362	263	255	403	386
	Fever ...	114	66	75	152	128
April	Total ...	328	341	323	396	454
	Fever ...	75	89	113	155	146
May	Total ...	359	306	375	409	459
	Fever ...	70	75	131	157	132
June	Total ...	328	285	369	400	481
	Fever ...	64	73	136	137	153
July	Total ...	377	402	443	554	635
	Fever ...	83	110	171	234	197
August	Total ...	431	469	434	600	562
	Fever ...	88	155	195	275	243
September	Total ...	421	394	510	516	553
	Fever ...	90	143	271	254	266
October	Total ...	444	471	686	550	639
	Fever ...	126	167	440	263	361
November	Total ...	429	346	449	488	573
	Fever ...	164	132	256	200	276
December	Total ...	291	303	375	409	460
	Fever ...	262	111	166	146	148

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